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(45) **Date of Patent:** **Oct. 20, 2015**

(54) **RESISTANCE HEATING ELEMENT AND HEATING MEMBER AND FUSING DEVICE EMPLOYING THE SAME**

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(30) **Foreign Application Priority Data**

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(51) **Int. Cl.**

G03G 15/20	(2006.01)
H01C 7/02	(2006.01)
H01C 7/04	(2006.01)
H05B 1/02	(2006.01)

(52) **U.S. Cl.**

CPC ***H01C 7/021*** (2013.01); ***G03G 15/206*** (2013.01); ***G03G 15/2057*** (2013.01); ***H01C 7/041*** (2013.01); ***H05B 1/0241*** (2013.01); *G03G 2215/2035* (2013.01); *H05B 2203/019* (2013.01); *H05B 2203/02* (2013.01)

(58) **Field of Classification Search**

CPC G03G 15/206; G03G 15/2053; G03G 15/2057; H01C 7/021; H01C 7/041; H05B 1/0241

USPC 399/333, 330, 329, 328

See application file for complete search history.

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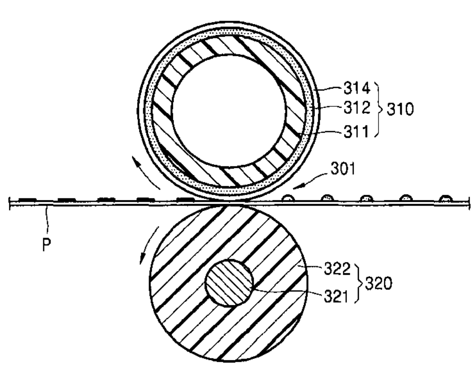
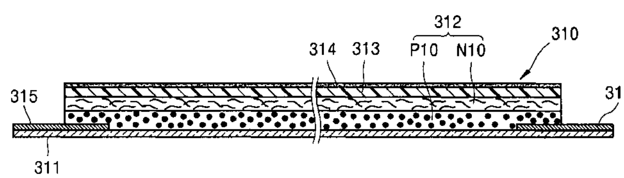
(74) *Attorney, Agent, or Firm* — Harness, Dickey & Pierce

(57) **ABSTRACT**

A resistance heating element includes a positive temperature coefficient resistance heating layer having a positive temperature coefficient, and a negative temperature coefficient resistance heating layer, which is connected to the positive temperature coefficient resistance heating layer and has a negative temperature coefficient.

18 Claims, 14 Drawing Sheets





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KR	10-2013-0097479		9/2013

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FIG. 1

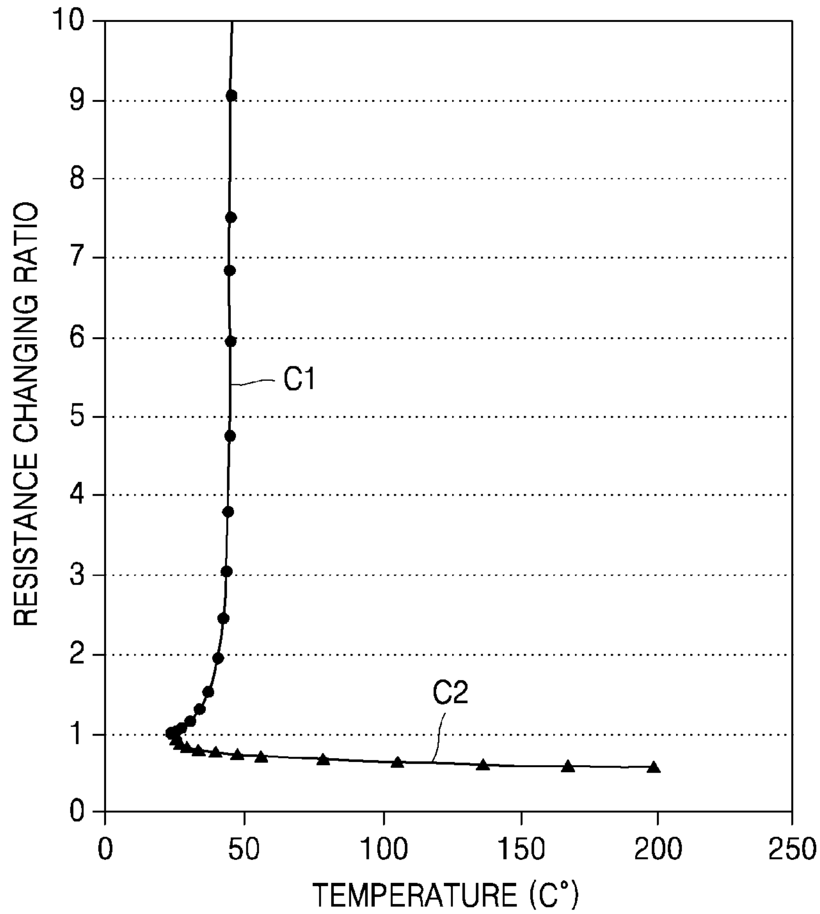

RESISTANCE CHANGING RATIO
TEMPERATURE (C°)
C1
C2
0
1
2
3
4
5
6
7
8
9
10
0
50
100
150
200
250

FIG. 2

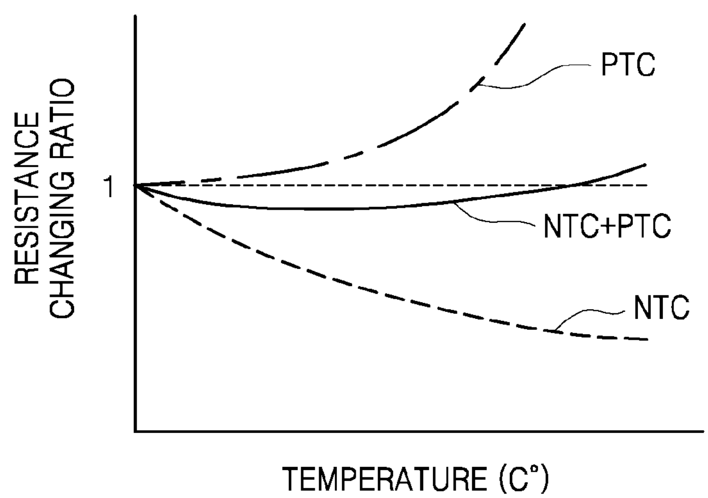

RESISTANCE CHANGING RATIO
TEMPERATURE (C°)
1
PTC
NTC+PTC
NTC

FIG. 3

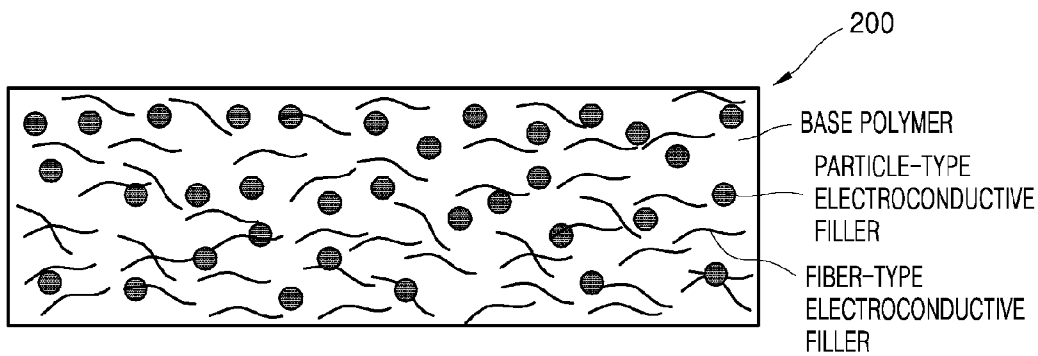

200
BASE POLYMER
PARTICLE-TYPE ELECTROCONDUCTIVE FILLER
FIBER-TYPE ELECTROCONDUCTIVE FILLER

FIG. 4

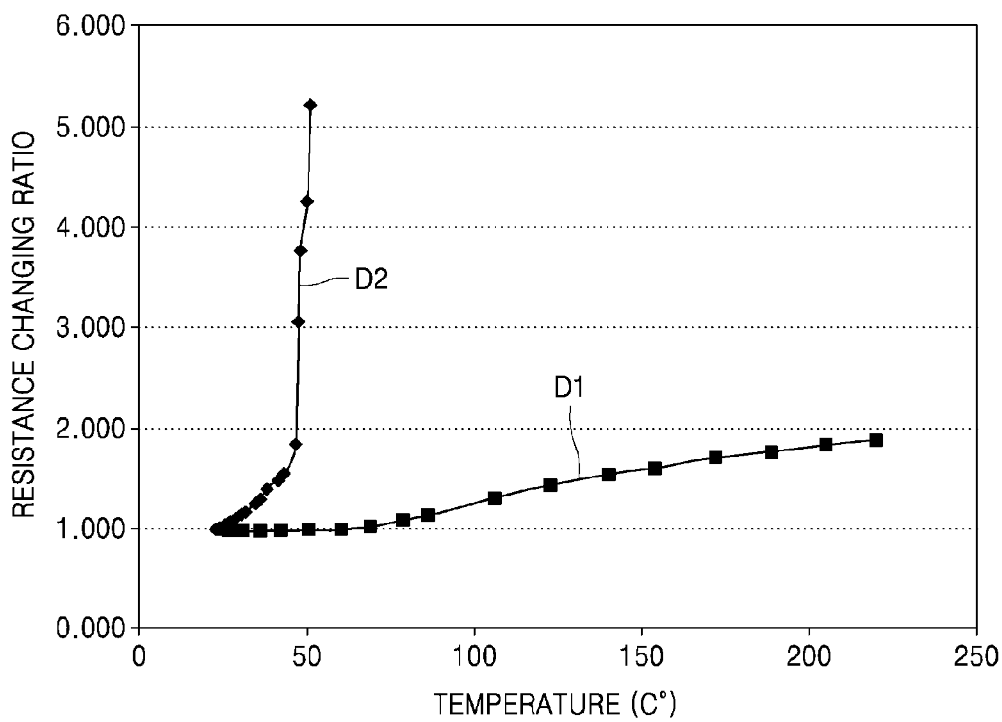
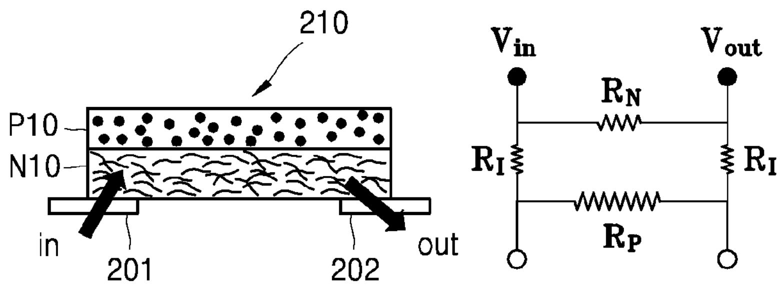
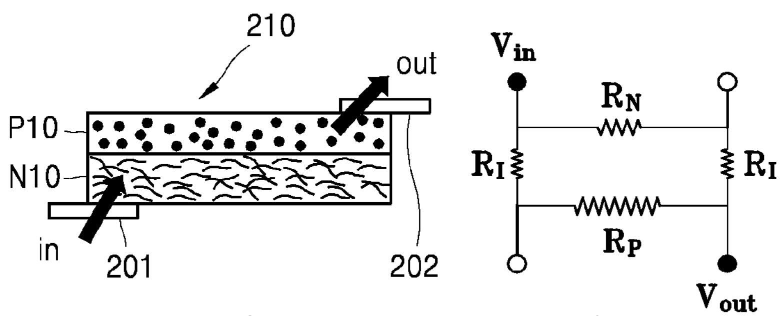

RESISTANCE CHANGING RATIO
6.000
5.000
4.000
3.000
2.000
1.000
0.000
D2
D1
0
50
100
150
200
250
TEMPERATURE (C°)

FIG. 5A



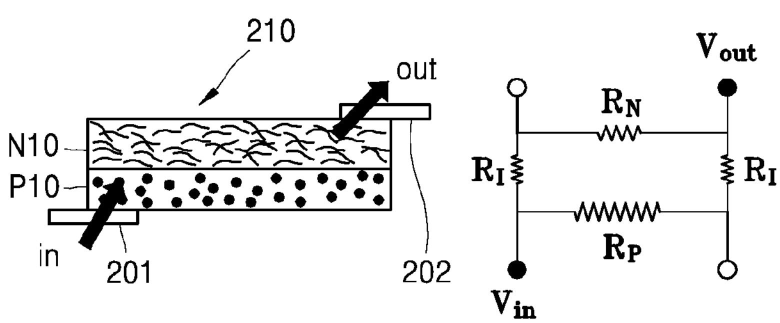
(PTC on NTC, NTC to NTC)

FIG. 5B



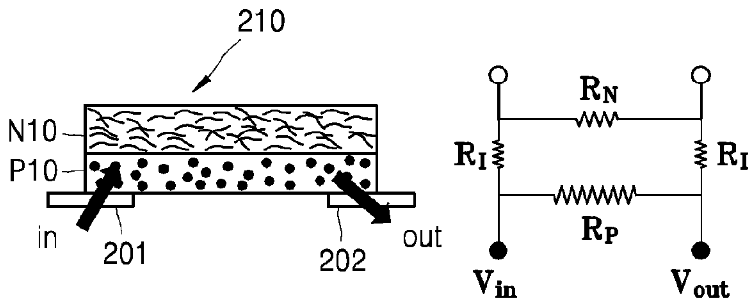
(PTC on NTC, NTC to PTC)

FIG. 5C



(NTC on PTC, PTC to NTC)

FIG. 5D



(NTC on PTC, PTC to PTC)

FIG. 6

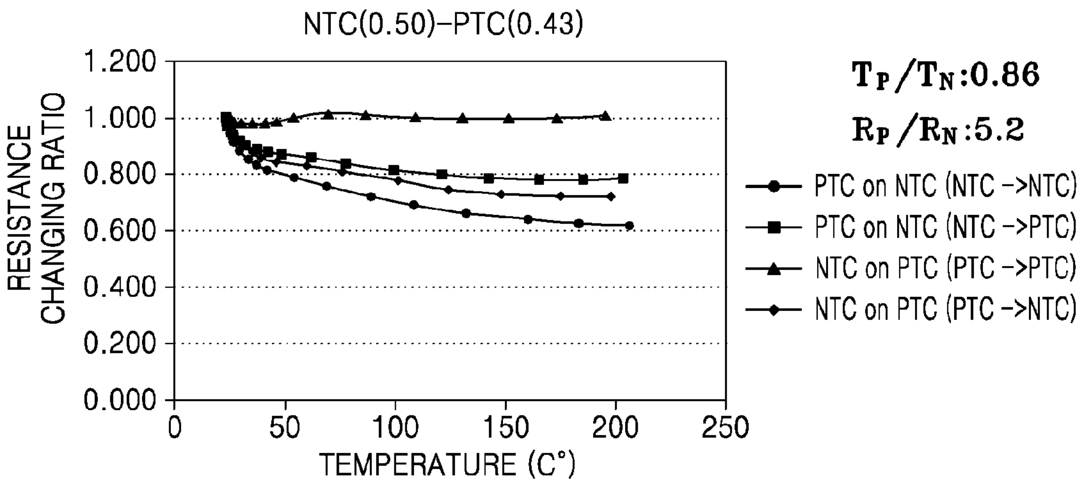


FIG. 7

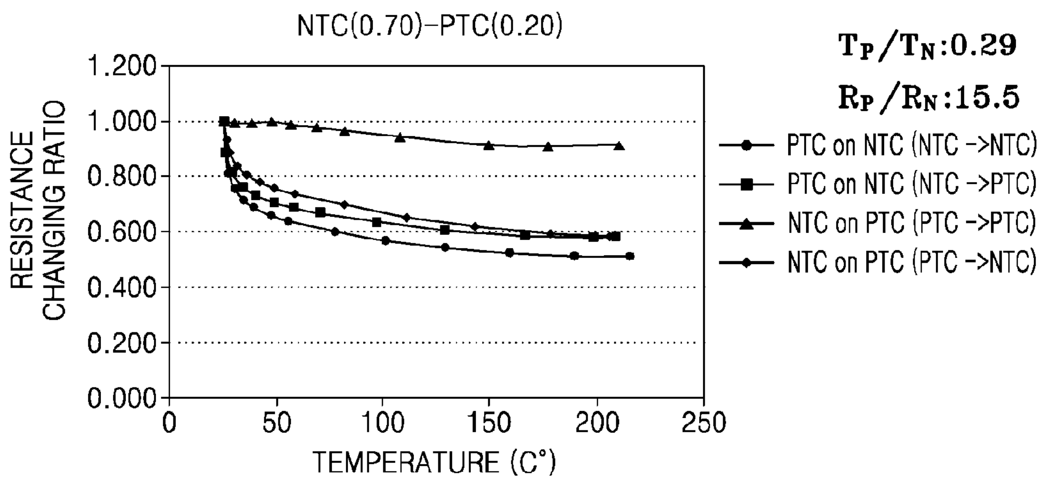

NTC(0.70)-PTC(0.20)
T_P/T_N:0.29
R_P/R_N:15.5
RESISTANCE CHANGING RATIO
1.200
1.000
0.800
0.600
0.400
0.200
0.000
0
50
100
150
200
250
TEMPERATURE (C°)
PTC on NTC (NTC ->NTC)
PTC on NTC (NTC ->PTC)
NTC on PTC (PTC ->PTC)
NTC on PTC (PTC ->NTC)

FIG. 8A

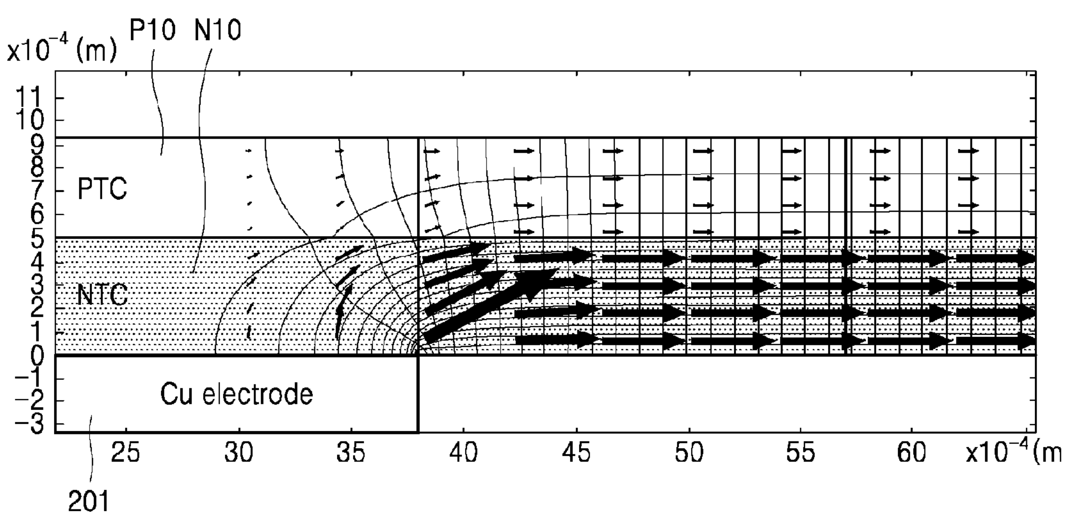
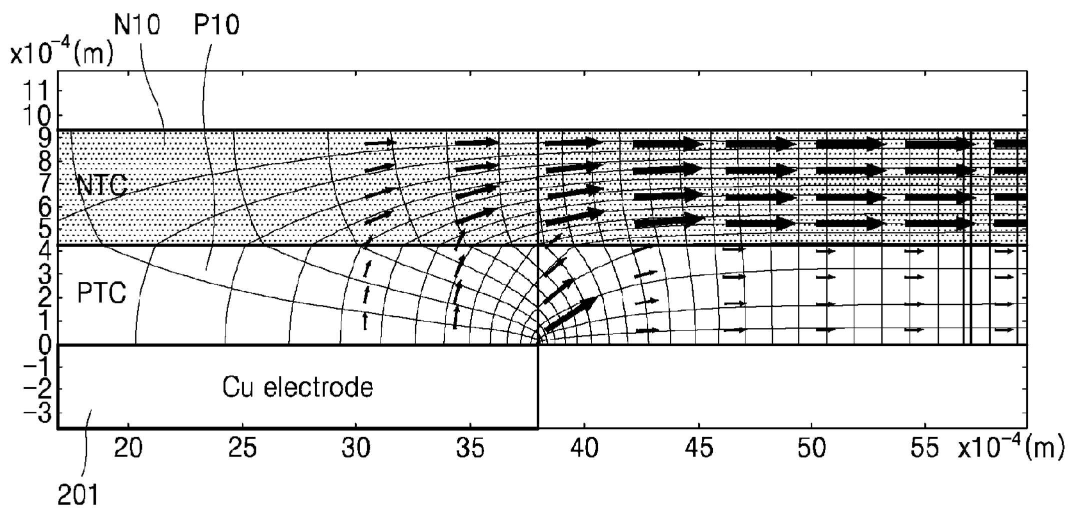
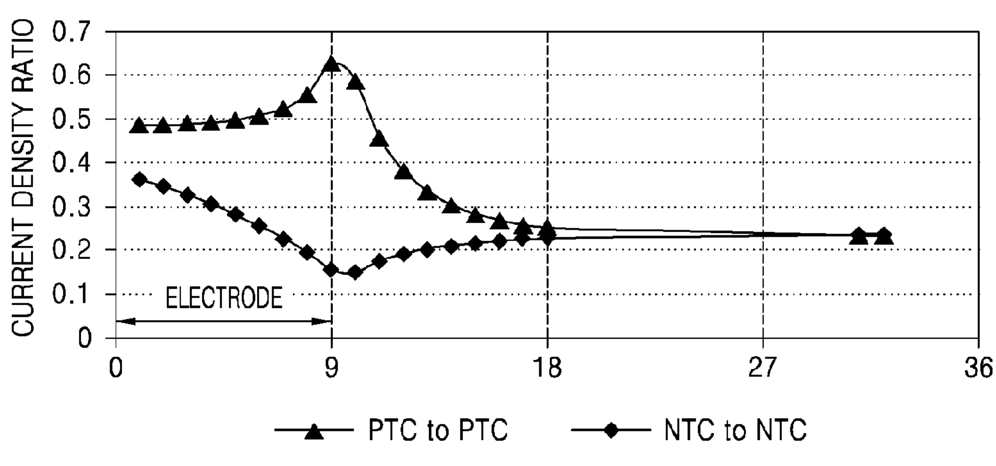

x10^{-4} (m)
P10
N10
PTC
NTC
Cu electrode
201
25
30
35
40
45
50
55
60
x10^{-4}(m)

FIG. 8B



N10
P10
x10⁻⁴(m)
NTC
PTC
Cu electrode
201
x10⁻⁴(m)

FIG. 8C



CURRENT DENSITY RATIO
ELECTRODE
PTC to PTC
NTC to NTC

FIG. 9A

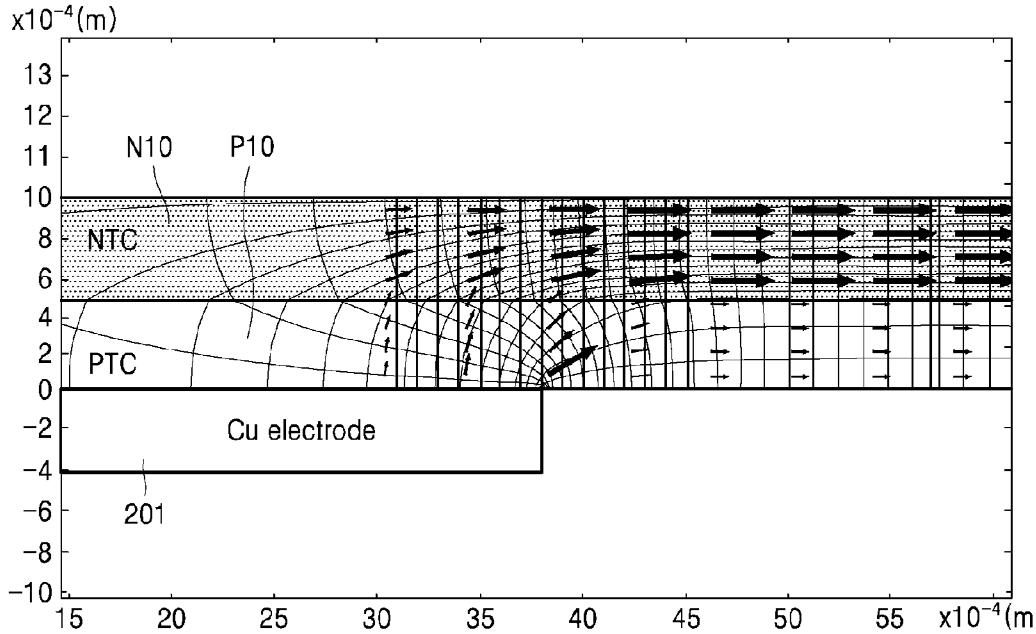

x10^-4 (m)
13
12
11
10
8
6
4
2
0
−2
−4
−6
−8
−10
N10
P10
NTC
PTC
Cu electrode
201
15
20
25
30
35
40
45
50
55
x10^-4 (m)

FIG. 9B

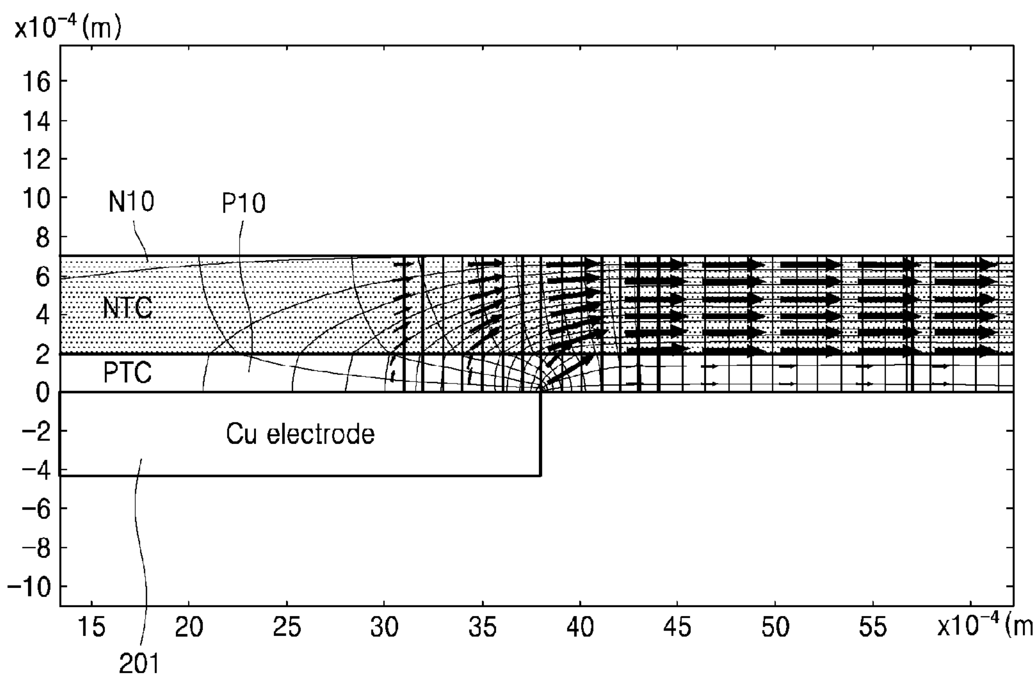

x10^-4 (m)
16
14
12
10
8
6
4
2
0
−2
−4
−6
−8
−10
N10
P10
NTC
PTC
Cu electrode
201
15
20
25
30
35
40
45
50
55
x10^-4 (m)

FIG. 9C

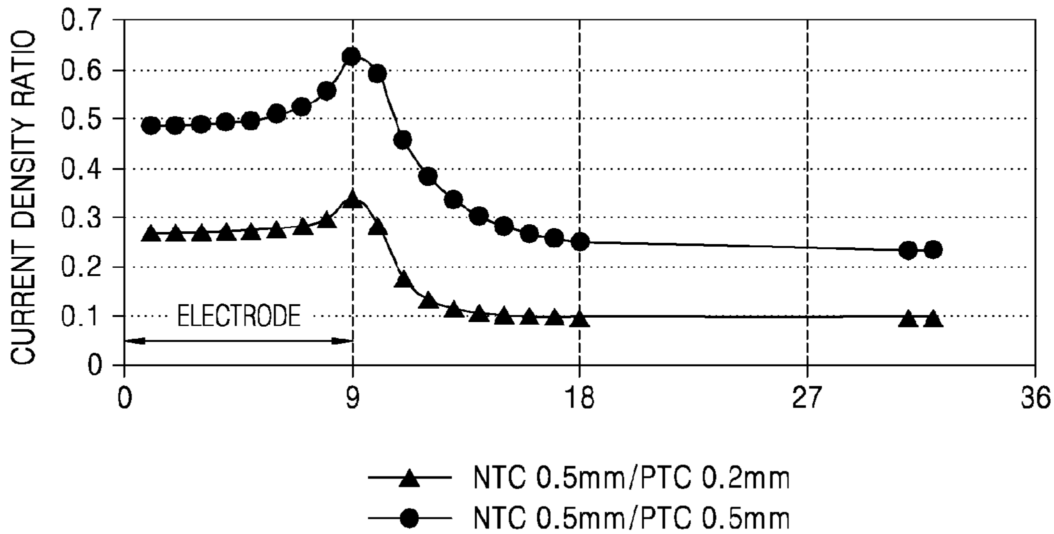

CURRENT DENSITY RATIO
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
ELECTRODE
0
9
18
27
36
NTC 0.5mm/PTC 0.2mm
NTC 0.5mm/PTC 0.5mm

FIG. 10

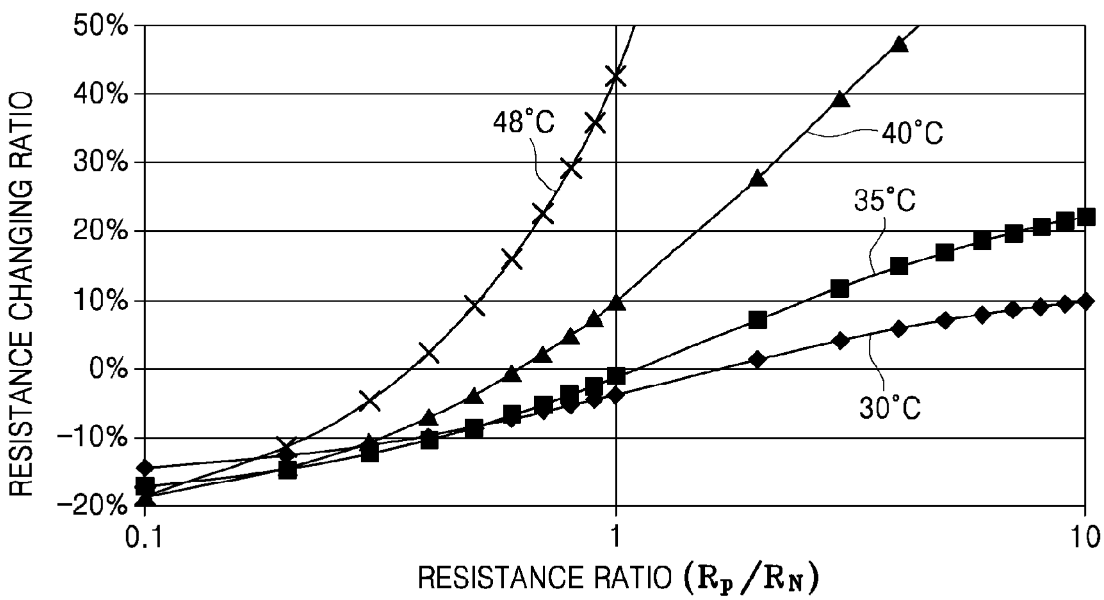

RESISTANCE CHANGING RATIO
50%
40%
30%
20%
10%
0%
−10%
−20%
48°C
40°C
35°C
30°C
0.1
1
10
RESISTANCE RATIO (R_P/R_N)

FIG. 11

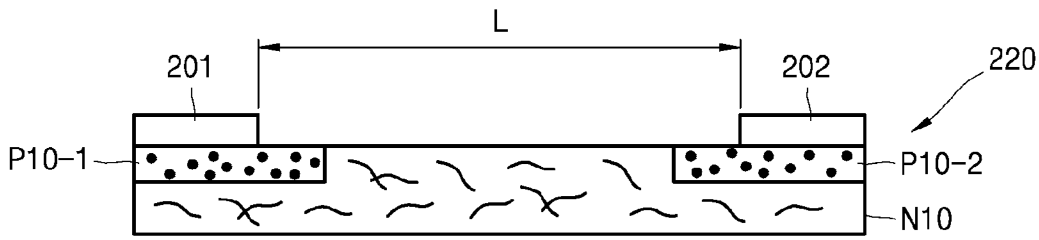

L
201
202
220
P10-1
P10-2
N10

FIG. 12

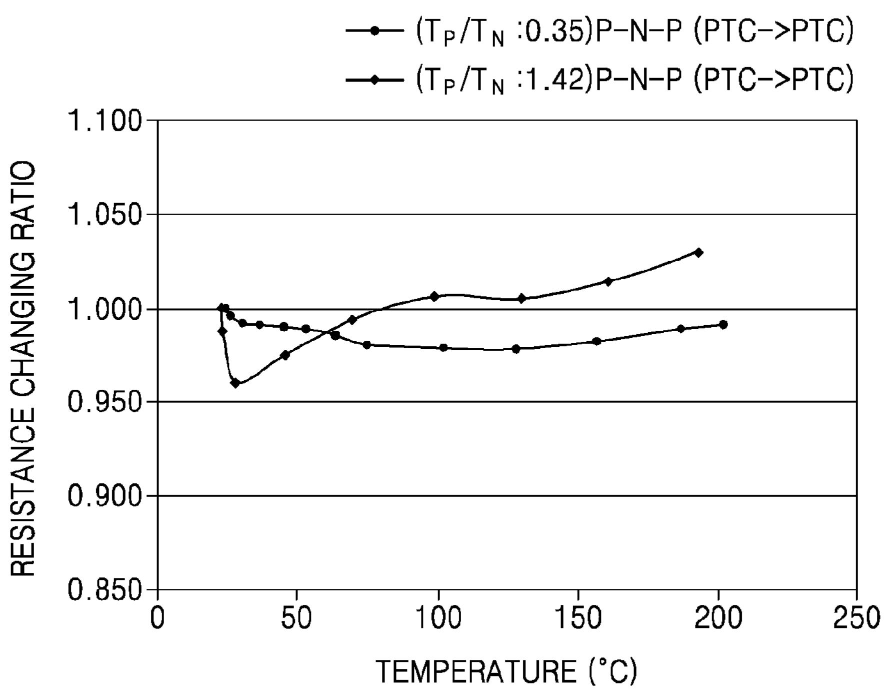

(TP/TN :0.35)P-N-P (PTC->PTC)
(TP/TN :1.42)P-N-P (PTC->PTC)
1.100
1.050
1.000
0.950
0.900
0.850
RESISTANCE CHANGING RATIO
0
50
100
150
200
250
TEMPERATURE (°C)

FIG. 13A

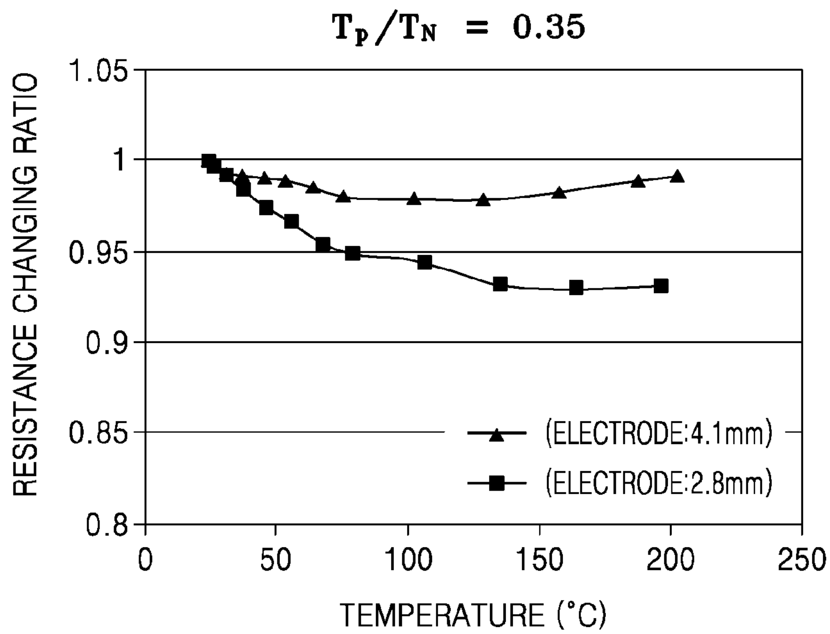


FIG. 13B

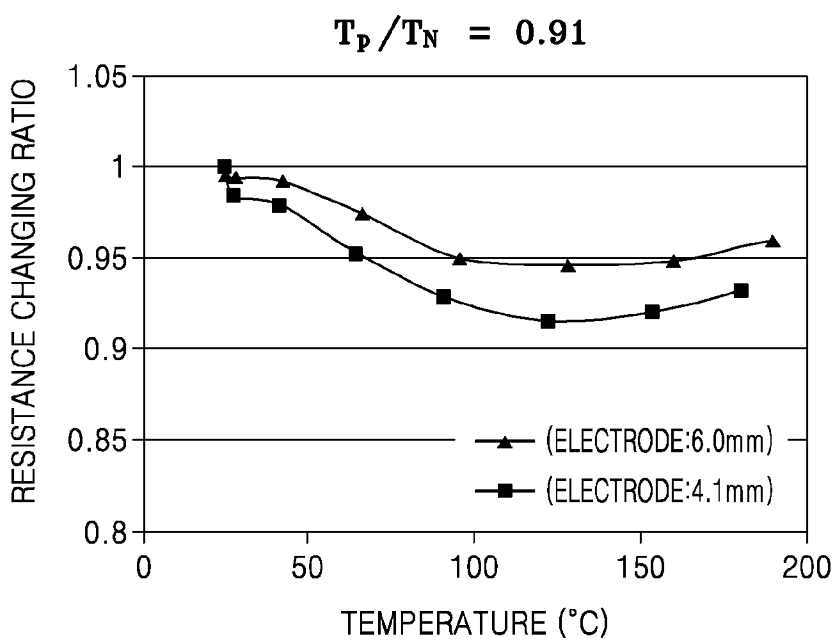


FIG. 13C

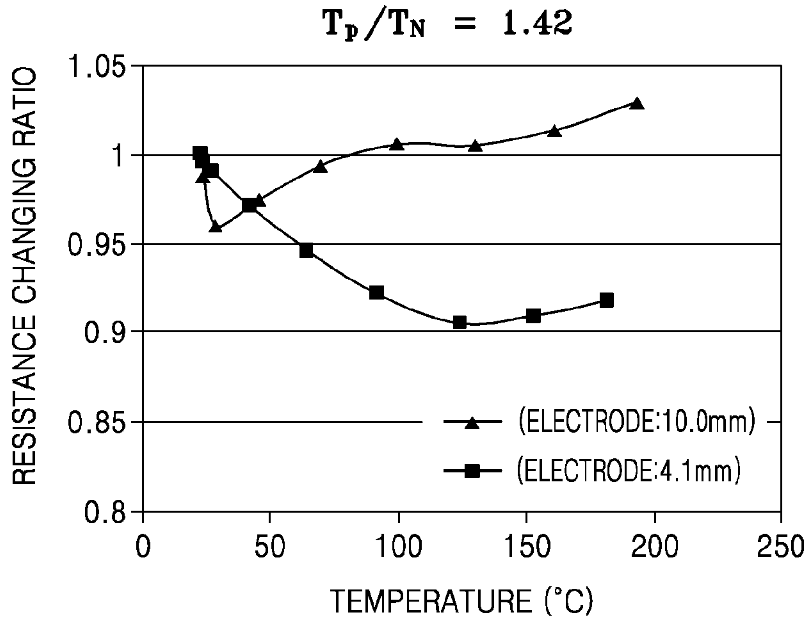


FIG. 14

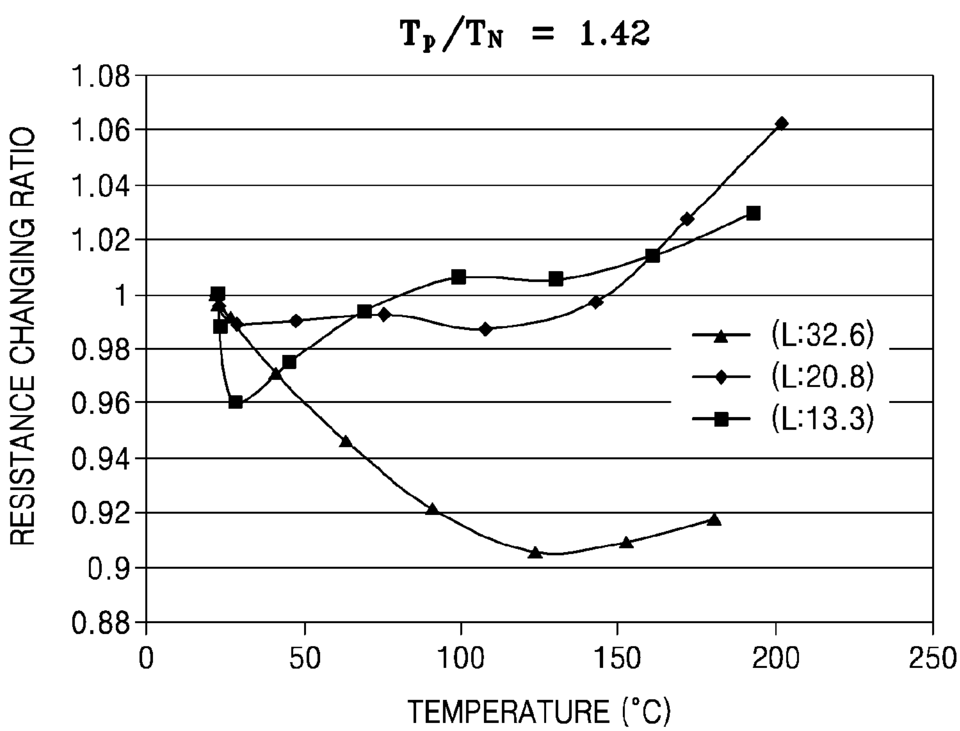


FIG. 15

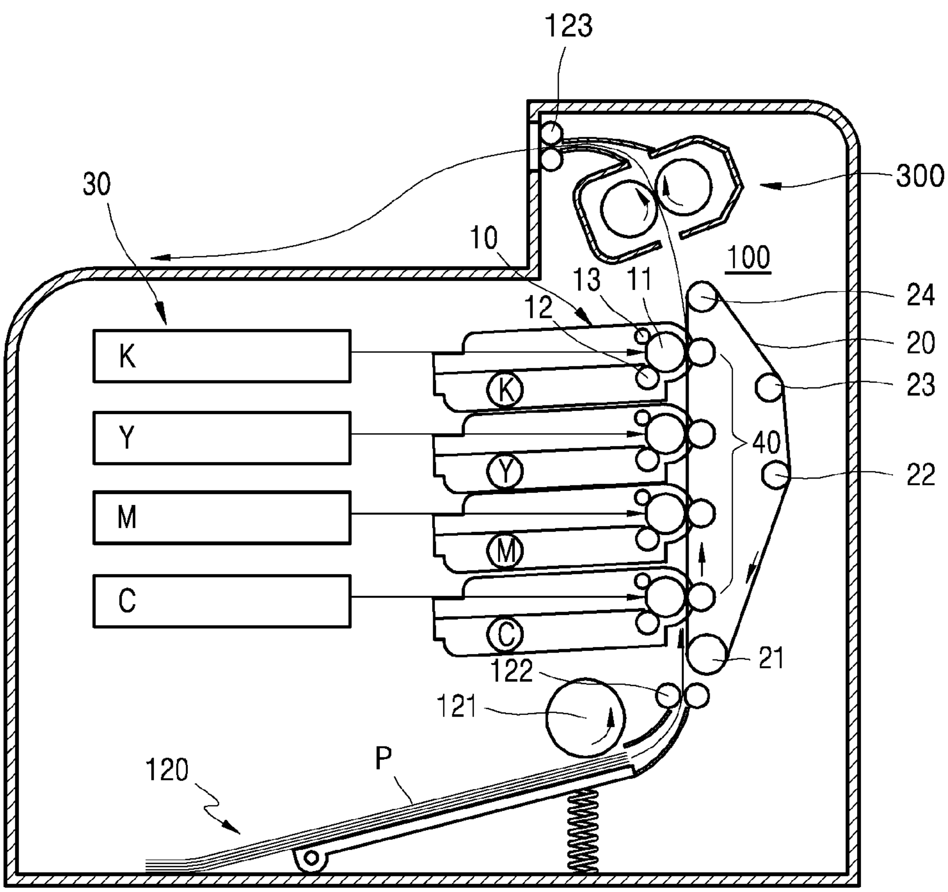


FIG. 16

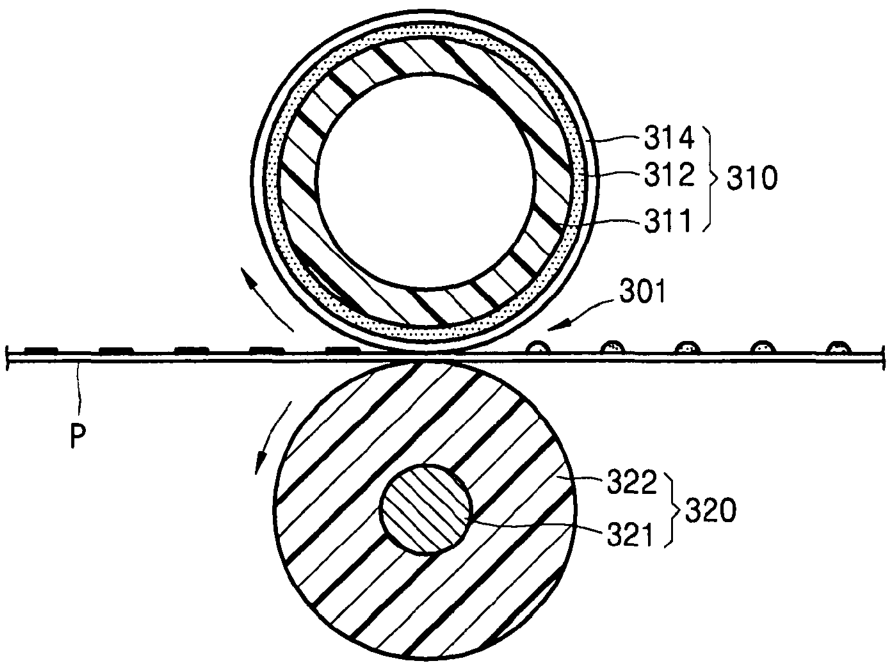


FIG. 17

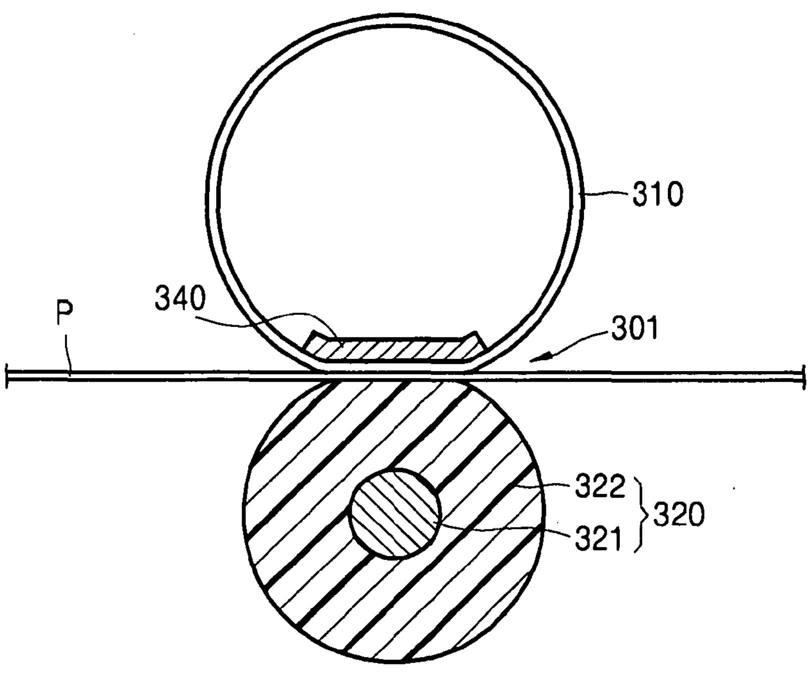


FIG. 18

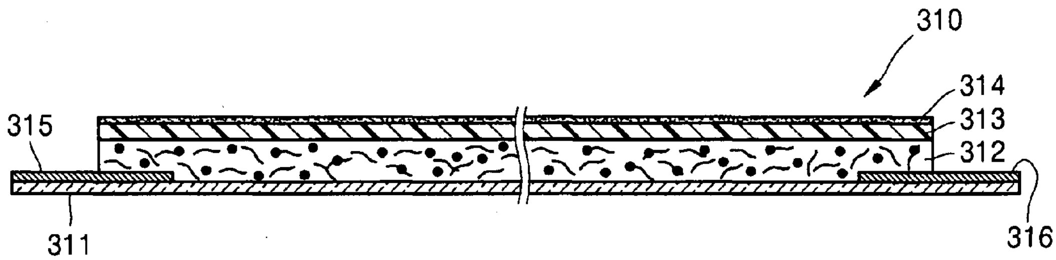


FIG. 19

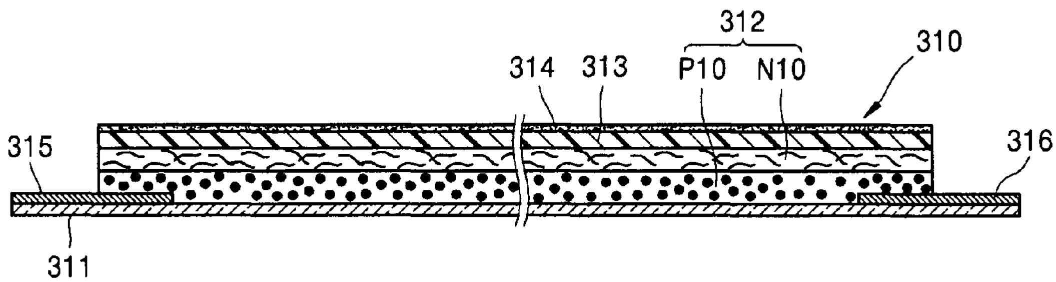


FIG. 20

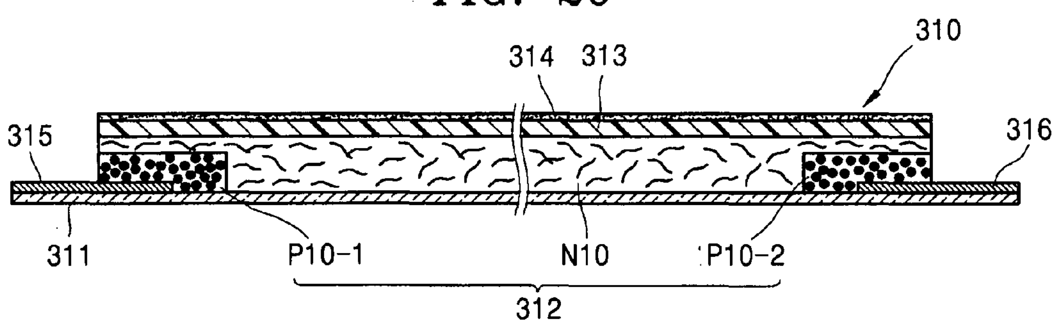
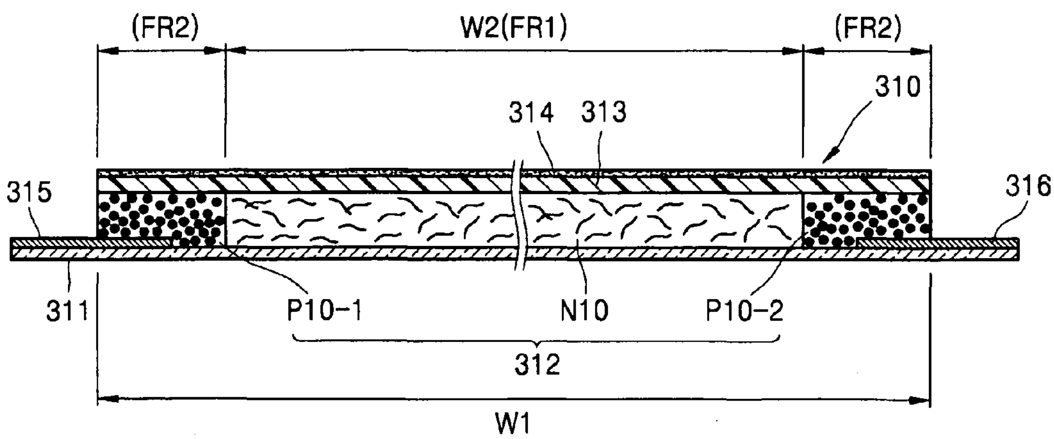


FIG. 21



RESISTANCE HEATING ELEMENT AND HEATING MEMBER AND FUSING DEVICE EMPLOYING THE SAME

This application claims priority to Korean Patent Application No. 10-2013-0006064, filed on Jan. 18, 2013, and all the benefits accruing therefrom under 35 U.S.C. §119, the content of which in its entirety is herein incorporated by reference.

BACKGROUND

1. Field

The disclosure relates to a resistance heating element, and a heating member and a fusing device including the resistance heating element.

2. Description of the Related Art

A relative change of electric resistance according to change of temperature of a resistance heating element is defined as a temperature coefficient of electrical resistance. A resistance heating element is referred to as having a negative temperature coefficient ("NTC") tendency when the resistance thereof decreases as temperature increases, and a resistance heating element is referred to as having a positive temperature coefficient ("PTC") tendency when the resistance thereof increases as temperature increases. While most of materials exhibit PTC tendencies, nano-composite materials may exhibit NTC tendencies according to material properties of matrixes and combinations of fillers.

Resistance heating elements may be applied to various fields. For example, a resistance heating element may be applied to a fusing device of an electrophotographic image forming apparatus. An electrophotographic image forming apparatus forms a visible toner image on an image receptor by supplying a toner to an electrostatic latent image formed on the image receptor, transfers the toner image to a printing medium, and fuses the transferred toner image to the printing medium. A toner is typically manufactured by adding various functional additives, such as colorants, to a base resin. A fusing operation includes applications of heat and pressure to a toner. Substantial portion of energy consumed by an electrophotographic image forming apparatus is consumed during a fusing operation. A resistance heating element may be employed as a heating member for applying heat to a toner. At a fusing device of an image forming apparatus, if resistance of a resistance heating element changes significantly during the initial warm-up, applied power changes significantly during a short period of time such that overheating may occur.

SUMMARY

Provided are embodiments of a resistance heating element with a relatively small resistance changing ratio during heating, and embodiments of a heating member and a fusing device including the resistance heating element.

Provided are embodiments of a resistance heating element with quick heating and improved durability, and embodiments of a heating member and a fusing device including the resistance heating element.

Additional aspects will be set forth in part in the description which follows and, in part, will be apparent from the description, or may be learned by practice of the presented embodiments.

According to an embodiment of the invention, a resistance heating element includes a positive temperature coefficient ("PTC") resistance heating layer having a positive temperature coefficient; and a negative temperature coefficient ("NTC") resistance heating layer which is electrically connected to the PTC resistance heating layer and has a negative temperature coefficient.

In an embodiment, the PTC resistance heating layer may include a first base polymer and first electroconductive fillers which are dispersed in the first base polymer and form a first conductive network, and the NTC resistance heating layer may include a second base polymer and second electroconductive fillers which are dispersed in the second base polymer and form a second conductive network.

In an embodiment, an aspect ratio of the first electroconductive fillers may be less than about 10, and an aspect ratio of the second electroconductive fillers may be equal to or greater than about 10.

In an embodiment, a resistance changing ratio of the PTC resistance heating layer according to temperature may be equal to or greater than about 10%. A resistance changing ratio of the NTC resistance heating layer according to temperature may be equal to or greater than about 10%.

In an embodiment, the resistance heating element may further include an input electrode and an output electrode which supply currents to the resistance heating element, where the PTC resistance heating layer and the NTC resistance heating layer may be one of a structure in which the PTC resistance heating layer and the NTC resistance heating layer are stacked, a structure in which the NTC resistance heating layer is arranged on and between first and second portions of the PTC resistance heating layers, which are spaced apart from each other, and a structure in which the NTC resistance heating layer is arranged between the first and second portions of the PTC resistance heating layer, and the input electrode and the output electrode may have one of a structure in which the input electrode and the output electrode are connected to the PTC resistance heating layer, a structure in which the input electrode and the output electrode are connected to the NTC resistance heating layer, and a structure in which the input electrode is connected to one of the PTC resistance heating layer and the NTC resistance heating layer and the output structure is connected to the other of the PTC resistance heating layer and the NTC resistance heating layer.

In an embodiment, a resistance ratio of resistance of the PTC resistance heating layer with respect to resistance of the NTC resistance heating layer may have a predetermined value, such that the resistance changing ratio of the resistance heating element is within about ±40%.

In an embodiment, the resistance heating element may further include an input electrode and an output electrode, which supply currents to the resistance heating element, where the input electrode and the output electrode may be connected to one of the PTC resistance heating layer and the NTC resistance heating layer, which has greater resistance.

In an embodiment, a resistance changing ratio of the other of the PTC resistance heating layer and the NTC resistance heating layer, to which the input electrode and the output electrode are not connected, may be less than a resistance changing ratio of the one of the PTC resistance heating layer and the NTC resistance heating layer, to which the input electrode and the output electrode are connected.

In an embodiment, the input electrode and the output electrode may be connected to the PTC resistance heating layer, and a resistance ratio of resistance of the PTC resistance heating layer with respect to resistance of the NTC resistance heating layer may be greater than or equal to about 2.

According to another embodiment of the invention, a heating member includes an input electrode and an output elec-

trode; and the resistance heating element which generates heat using electricity supplied via the input electrode and the output electrode.

In an embodiment, the supporting unit may have a hollow pipe-like shape or a belt-like shape.

According to another embodiment of the invention, a fusing device includes the heating member; and a nib forming unit, which faces the heating member and forms a fusing nib.

BRIEF DESCRIPTION OF THE DRAWINGS

These and/or other features will become apparent and more readily appreciated from the following description of the embodiments, taken in conjunction with the accompanying drawings, of which:

FIG. **1** is a graph of resistance change ratio versus temperature showing negative temperature coefficient ("NTC") characteristics and positive temperature coefficient ("PTC") characteristics of a resistance heating element;

FIG. **2** is a graph of resistance change ratio versus temperature showing controlling of a resistance changing ratio to within a predetermined range;

FIG. **3** is a diagram showing an embodiment of an resistance heating element, which is a hybrid type resistance heating element;

FIG. **4** is a graph showing resistance changing ratio versus temperature of the hybrid type resistance heating element shown in FIG. **3**;

FIGS. **5**A to **5**D are diagrams showing embodiments of a resistance heating element having a stacked structure and electrodes;

FIG. **6** is a graph showing resistance changing ratio versus temperature the embodiments of the resistance heating element and the electrodes shown in FIGS. **5**A to **5**D, where resistance ratio is 5.2;

FIG. **7** is a graph showing resistance changing ratio versus temperature of the embodiment of the resistance heating element and the electrodes shown in FIGS. **5**A to **5**D, where resistance ratio is 15.5;

FIGS. **8**A and **8**B are diagrams showing directions of current flows and current density in an embodiment of a resistance heating element having a PTC to NTC structure and in an embodiment of a resistance heating element having an NTC to PTC structure;

FIG. **8**C is a graph showing current density ratios in an embodiment of a resistance heating element having the PTC to NTC structure and in an embodiment of a resistance heating element having the NTC to PTC structure;

FIGS. **9**A and **9**B are diagrams showing current flows according to thickness of a PTC resistance heating layer in an NTC to PTC structure;

FIG. **9**C is a graph showing current density ratios in the structures shown in FIGS. **9**A and **9**B;

FIG. **10** is a graph showing resistance changing ratio versus resistance ratio;

FIG. **11** is a diagram showing an embodiment of an resistance heating element, which is an island type resistance heating element;

FIG. **12** is a diagram showing a relationship between temperature and resistance changing ratio according to thickness ratio in the island type resistance heating element shown in FIG. **11**;

FIGS. **13**A to **13**C are graphs showing a relationship between temperature and resistance changing ratio according to thickness ratio and length of an electrode in the island type resistance heating element shown in FIG. **11**;

FIG. **14** is a graphs showing a relationship between temperatures and resistance changing ratios according to conductive lengths in the island type resistance heating element shown in FIG. **11**;

FIG. **15** is a cross-sectional view of an embodiment of an electrophotographic image forming apparatus including a fusing device including a heating element according to the invention;

FIG. **16** is a schematic sectional view of an embodiment of the fusing device, which is a roller-type fusing device, according to the invention;

FIG. **17** is a schematic sectional view of an embodiment of the fusing device, a belt-type fusing device, according to the invention;

FIG. **18** is a cross-sectional view of an embodiment of a heating element according to the invention;

FIG. **19** is a cross-sectional view of an alternative embodiment of a heating element according to the invention;

FIG. **20** is a cross-sectional view of another alternative embodiment of a heating element according to the invention; and

FIG. **21** is a cross-sectional view of another alternative embodiment of a heating element according to the invention.

DETAILED DESCRIPTION

The invention will be described more fully hereinafter with reference to the accompanying drawings, in which exemplary embodiments of the invention are shown. This invention may, however, be embodied in many different forms, and should not be construed as limited to the embodiments set forth herein. Rather, these embodiments are provided so that this disclosure will be thorough and complete, and will fully convey the scope of the invention to those skilled in the art. Like reference numerals refer to like elements throughout.

It will be understood that when an element or layer is referred to as being "on," "connected to" or "coupled to" another element or layer, the element or layer can be directly on, connected or coupled to the other element or layer or intervening elements or layers may be present. In contrast, when an element is referred to as being "directly on," "directly connected to" or "directly coupled to" another element or layer, there are no intervening elements or layers present. Like numbers refer to like elements throughout. As used herein, the term "and/or" includes any and all combinations of one or more of the associated listed items.

It will be understood that, although the terms first, second, third, etc., may be used herein to describe various elements, components, regions, layers and/or sections, these elements, components, regions, layers and/or sections should not be limited by these terms. These terms are only used to distinguish one element, component, region, layer or section from another element, component, region, layer or section. Thus, a first element, component, region, layer or section discussed below could be termed a second element, component, region, layer or section without departing from the teachings of the invention.

Spatially relative terms, such as "beneath", "below", "lower", "above", "upper" and the like, may be used herein for ease of description to describe one element or feature's relationship to another element(s) or feature(s) as illustrated in the figures. It will be understood that the spatially relative terms are intended to encompass different orientations of the device in use or operation, in addition to the orientation depicted in the figures. For example, if the device in the figures is turned over, elements described as "below" or "beneath" other elements or features would then be oriented "above" the other elements or features. Thus, the exemplary term "below" can encompass both an orientation of above and below. The device may be otherwise oriented (rotated 90 degrees or at other orientations) and the spatially relative descriptors used herein interpreted accordingly.

The terminology used herein is for the purpose of describing particular embodiments only and is not intended to be limiting of the invention. As used herein, the singular forms "a," "an" and "the" are intended to include the plural forms as well, unless the context clearly indicates otherwise. It will be further understood that the terms "includes" and/or "including," when used in this specification, specify the presence of stated features, integers, steps, operations, elements, and/or components, but do not preclude the presence or addition of one or more other features, integers, steps, operations, elements, components, and/or groups thereof.

"About" or "approximately" as used herein is inclusive of the stated value and means within an acceptable range of deviation for the particular value as determined by one of ordinary skill in the art, considering the measurement in question and the error associated with measurement of the particular quantity (i.e., the limitations of the measurement system). For example, "about" can mean within one or more standard deviations, or within ±30%, 20%, 10%, 5% of the stated value.

Unless otherwise defined, all terms (including technical and scientific terms) used herein have the same meaning as commonly understood by one of ordinary skill in the art to which this invention belongs. It will be further understood that terms, such as those defined in commonly used dictionaries, should be interpreted as having a meaning that is consistent with their meaning in the context of the relevant art and will not be interpreted in an idealized or overly formal sense unless expressly so defined herein.

Embodiments of the invention are described herein with reference to cross-section illustrations that are schematic illustrations of idealized embodiments (and intermediate structures) of the invention. As such, variations from the shapes of the illustrations as a result, for example, of manufacturing techniques and/or tolerances, are to be expected. Thus, embodiments of the invention should not be construed as limited to the particular shapes of regions illustrated herein but are to include deviations in shapes that result, for example, from manufacturing. For example, a region illustrated or described as flat may, typically, have rough and/or nonlinear features. Moreover, sharp angles that are illustrated may be rounded. Thus, the regions illustrated in the figures are schematic in nature and their shapes are not intended to illustrate the precise shape of a region and are not intended to limit the scope of the claims set forth herein.

Hereinafter, embodiments of a resistance heating element and embodiments of a heating member and a fusing device including the resistance heating element according to the invention will be described in further detail with reference to the accompanying drawings.

An embodiment of a resistance heating element may be a polymer resistance heating element that includes a base polymer and electroconductive fillers distributed in the base polymer. In such an embodiment, the base polymer may be a thermally stable polymer. In one embodiment, for example, the base polymer may be a highly thermal-resistant polymer, such as silicon rubber, polyimide, polyamide, polyimide-amide, and fluoropolymers. In one embodiment, where the base polymer includes a fluoropolymer, the fluoropolymer may be a perfluoroelastomer, such as perfluoroalkoxy polymer ("PFA") and polytetrafluoroethylenes ("PTFE"), for example, or a fluorinated polymer, such as fluorinated polyetherketones ("PEEK") and fluorinated ethylene propylene ("FEP"), for example. In an embodiment, the base polymer may include at least one of the above-stated polymers. In one embodiment, for example, the base polymer may be one of the above-stated polymers, or a blend or a copolymer of at least two of the above-stated polymers. In such an embodiment, the base polymer may include a material based on a predetermined hardness of the base polymer according to the application of the resistance heating element including the base polymer.

In an embodiment, the electroconductive fillers of the resistance heating element may be metal fillers or carbon-based fillers, for example. In an embodiment, where the resistance heating element includes the metal fillers, the metal fillers may be metal particles, e.g., Ag, Ni, Cu, Fe, etc. In an embodiment, where the resistance heating element includes the carbon-based fillers, the carbon-based fillers may be carbon nanotubes ("CNT"), carbon black, carbon nanofibers, graphene, expanded graphite, graphite nanoplatelets or graphite oxide ("GO"), for example. In such an embodiment, the electroconductive fillers may be the above-stated particles coated with other conductive materials. In such an embodiment, the electroconductive fillers may be the above-stated particles doped with conductive materials. The electroconductive fillers may be any of various types of electroconductive filler, such as fiber type electroconductive filler or particle type electroconductive filler, for example.

In such an embodiment, where the resistance heating member includes the based polymer and the electroconductive fillers, the electroconductive fillers are distributed in the base polymer and form an electroconductive network. In general, CNTs may form a conductor or a resistor having conductivity in a range from about 10^{-4} siemens per meter (S/m) to about 100 siemens per meter (S/m) according to content thereof. The CNT has high conductivity similar to conductivities of metals and has substantially low density. Therefore, heat capacity (heat capacity=density×specific heat) per unit volume of CNT is about 3 to 4 times lower than heat capacity per unit volume of a conventional resistive material. In an embodiment, where the electroconductive fillers of the resistance heating element include CNTs, temperature of the resistance heating element may substantially rapidly change. In one embodiment, for example, a heating member for a fusing device of a printer may include a resistance heating element including electroconductive fillers, such that warm-up time from print stand-by state to printing state may be reduced, and thus a first page may be quickly printed. In such an embodiment, a preheating process of a heating member at a stand-by state may be substantially reduced or effectively omitted, such that power consumption may be reduced.

Electric resistance of a resistance heating element is changed as temperature increases. Change of electric resistance depends on type of electroconductive fillers. In one embodiment, for example, the resistance heating element includes particle type electroconductive fillers, and the resistance heating element exhibits positive temperature coefficient ("PTC") characteristics. In such an embodiment, as temperature increases, electric resistance of the resistance heating element increases. In one embodiment, for example, where the resistance heating element includes fiber type electroconductive fillers, the resistance heating element exhibits negative temperature coefficient ("NTC") characteristics. In such an embodiment, as temperature increases, electric resistance of the resistance heating element decreases.

FIG. **1** is a graph of resistance change ratio versus temperature showing negative temperature coefficient ("NTC") characteristics and positive temperature coefficient ("PTC") characteristics of a resistance heating element. FIG. **1** shows a result of measuring electric resistance changing ratio of a resistance heating element according to temperature in an embodiment where the resistance heating element includes the particle type electroconductive fillers and in an embodiment where the resistance heating element includes the fiber type electroconductive fillers. In such embodiments, the resistance heating element includes polydimethylsiloxane ("PDMS"), which is a type of silicon rubbers as the base polymer. In such embodiments, the resistance heating element may include carbon black of about 150 parts per hundred resin ("phr") as the particle type electroconductive fillers, and include multi-walled carbon nanotubes ("MWCNT"s) of about 12 phr as the fiber type electroconductive fillers. The aspect ratio of the MWCNTs is about 150 or higher. In the graph shown in FIG. **1**, the horizontal axis indicates temperature, and the vertical axis indicates resistance changing ratio. The resistance changing ratio is a ratio of resistance R of each temperature with respect to the resistance R_0 at the room temperature (e.g., about 25° C.). Referring to FIG. **1**, in an embodiment where the resistance heating element includes carbon black as the electroconductive fillers (C**1** in FIG. **1**), a PTC characteristic in which resistance rapidly increases while temperature of the resistance heating element is rising to about 50° C. is exhibited. In an embodiment where the resistance heating element includes CNTs as the electroconductive fillers (C**2** in FIG. **1**), an NTC characteristic in which resistance decreases to about 38% while temperature of the resistance heating element is rising to about 200° C. is exhibited. Although not shown in FIG. **1**, in an embodiment, where the content of the CNTs is increased to about 15 phr, resistance of the resistance heating element decreases by about 58%.

FIG. **2** is a graph of resistance change ratio versus temperature showing controlling of a resistance changing ratio to within a predetermined range. In an embodiment of the resistance heating element according to the invention, the resistance heating element includes a PTC resistance heating element having a PTC characteristic and a NTC resistance heating element having an NTC characteristic, which are electrically connected to each other, such that the resistance changing ratio of the resistance heating element according to increase of temperature may be controlled to be within a predetermined range as shown in FIG. **2**, and for example, resistance changing ratio of the PTC resistance heating layer according to temperature may be equal to or greater than 10%, and resistance changing ratio of the NTC resistance heating layer according to temperature may be equal to or greater than 10%.

(1) Hybrid Structure

FIG. **3** is a diagram showing an embodiment of a resistance heating element, which is a hybrid type resistance heating element. Referring to FIG. **3**, a resistance heating element **200** may be a hybrid type resistance heating element having a hybrid structure including a base polymer, and particle type electroconductive fillers (first electroconductive fillers) for applying PTC characteristics and fiber type electroconductive fillers (second electroconductive fillers) for applying NTC characteristics, which are mixed and dispersed into the base polymer. In such an embodiment, the particle type electroconductive fillers may be carbon black or fullerene, for example, and the fiber type electroconductive fillers may be CNTs, for example. Electroconductive fillers may be categorized into particle type and fiber type based on aspect ratio of the fillers, for example. In an embodiment, electroconductive fillers having an aspect ratio less than 10 may be defined as particle type electroconductive fillers, and electroconductive fillers having an aspect ratio equal to or greater than 10 may be defined as fiber type electroconductive fillers.

FIG. **4** is a graph showing resistance changing ratio versus temperature of the hybrid type resistance heating element shown in FIG. **3**. FIG. **4** shows a graph showing the resistance changing ratio of the resistance heating element **200** having the hybrid structure according to an embodiment of the invention as shown in FIG. **3**. The resistance heating element **200** having the hybrid structure including about 0.5 phr of MWCNTs having an aspect ratio equal to or greater than 150 and about 150 phr of carbon black, which are dispersed into the PDMS. In FIG. **4**, D**1** denotes the resistance changing ratio of an embodiment of the resistance heating element **200**, and D**2** denotes the resistance changing ratio in a comparative embodiment, where about 150 phr of carbon black is dispersed into the PDMS.

Referring to FIG. **4**, an embodiment of the resistance heating element **200** having the hybrid structure exhibits relatively weak PTC characteristics, where curve of the resistance changing ratio is relatively flat compared to the comparative embodiment in which only carbon black is added. In an embodiment, although the base polymer expands as temperature rises, the MWCNTs function as conductive bridges between carbon black, thereby suppressing rapid increase of resistance. Therefore, an embodiment of the resistance heating element **200** having small resistance change ratio (e.g., equal to or less than about ±40%, and more particularly, equal to or less than about ±10%) within a predetermined range of temperatures may be formed by controlling contents of particle type electroconductive fillers and fiber type electroconductive fillers.

(2) Stacked Structure (Parallel Structure)

FIGS. **5**A to **5**D are diagrams showing embodiments of a resistance heating element having a stacked structure and electrodes. In an embodiment, the resistance heating element may have a stacked structure, in which a PTC resistance heating layer P**10** and an NTC resistance heating layer N**10** are stacked. In such an embodiment, the PTC resistance heating layer P**10** may include a base polymer (e.g., a first base polymer) and particle type electroconductive fillers (e.g., first electroconductive fillers) that are dispersed in the first base polymer to form a conductive network (e.g., a first conductive network). In such an embodiment, the NTC resistance heating layer N**10** may include a base polymer (e.g., a second base polymer) and fiber type electroconductive fillers (e.g., second electroconductive fillers) that are dispersed in the second base polymer to form a conductive network (e.g., a second conductive network)

In the perspective of current path, a resistance heating element **210** having the stacked structure may be understood as the structure in which the PTC resistance heating layer P**10** and the NTC resistance heating layer N**10** are connected in parallel. FIGS. **5**A to **5**D show embodiments of a resistance heating element having the stacked structure, and an electric circuit and a total resistance corresponding thereto. In such embodiments, for example, the PTC resistance heating layer P**10** may be formed by dispersing about 150 phr of carbon black in PDMS, and the NTC resistance heating layer N**10** may be formed by dispersing about 12 phr of MWCNTs having an aspect ratio equal to or greater than 150 in PDMS.

FIG. **5**A shows an embodiment of a resistance heating element having a PTC on NTC structure in which the PTC resistance heating layer P**10** is stacked on the NTC resistance heating layer N**10**. Electrodes **201** and **202** are connected to the NTC resistance heating layer N**10**. In FIG. **5**A, an equivalent electric circuit (NTC to NTC) of the resistance heating element **210** is also shown. In the equivalent circuit in FIG.

5A, Vin and Vout denote input voltage and output voltage, respectively. The total resistance R_T of the resistance heating element **210** may be expressed as the equation below.

$$R_T = \frac{2R_N R_I + R_N R_P}{(R_N + R_P) + 2R_I}$$

In the above and below equations, R_P denotes resistance of the PTC resistance heating layer P**10**, R_N denotes resistance of the NTC resistance heating layer N**10**, R_1 denotes resistance of the interface between the PTC resistance heating layer P**10** and the NTC resistance heating layer N**10**, and R_T denotes the total resistance of the resistance heating element **210**.

FIG. **5**B shows an embodiment of a resistance heating element having a PTC on NTC structure in which the PTC resistance heating layer P**10** is stacked on the NTC resistance heating layer N**10**. In such an embodiment, the electrodes **201** and **202** are respectively connected to the NTC resistance heating layer N**10** and the PTC resistance heating layer P**10**. In FIG. **5**B, an equivalent electric circuit (NTC to PTC) of the resistance heating element **210** is also shown. The total resistance R_T may be expressed as the equation below.

$$R_T = \frac{(R_P + R_I)(R_N + R_I)}{(R_N + R_P) + 2R_I}$$

FIG. **5**C shows an embodiment of a resistance heating element having a NTC on PTC structure in which the NTC resistance heating layer N**10** is stacked on the PTC resistance heating layer P**10**. In such an embodiment, the electrodes **201** and **202** are respectively connected to the PTC resistance heating layer P**10** and the NTC resistance heating layer N**10**. In FIG. **5**C, an equivalent electric circuit (PTC to NTC) of the resistance heating element **210** is also shown. The total resistance R_T may be expressed as the equation below.

$$R_T = \frac{(R_P + R_I)(R_N + R_I)}{(R_N + R_P) + 2R_I}$$

FIG. **5**D shows an embodiment of a resistance heating element having a NTC on PTC structure in which the NTC resistance heating layer N**10** is stacked on the PTC resistance heating layer P**10**. In such an embodiment, the electrodes **201** and **202** are connected to the PTC resistance heating layer P**10**. In FIG. **5**D, an equivalent electric circuit (PTC to PTC) of the resistance heating element **210** is also shown. The total resistance R_T may be expressed as the equation below.

$$R_T = \frac{2R_P R_I + R_N R_P}{(R_N + R_P) + 2R_I}$$

In such embodiments, the structures shown in FIG. **5**B and FIG. **5**C exhibit substantially the same total resistance R_T, and resistance changing ratios according to change of temperature of the embodiments are thereby substantially the same as each other. In such embodiments, the structures shown in FIGS. **5**A and **5**D exhibit greater total resistances R_T than the structures shown in FIGS. **5**B and **5**C, where R_P is much greater than R_I and R_N.

When resistance of the PTC resistance heating layer P**10** and resistance of the NTC resistance heating layer N**10** are measured, the resistance of the PTC resistance heating layer P**10** is greater than the resistance of the NTC resistance heating layer N**10** when the PTC resistance heating layer P**10** and the NTC resistance heating layer N**10** have substantially the same size as each other. In one embodiment, for example, when resistance of a sample having a dimension of 18.8 millimeters (mm)×5.0 millimeters (mm)×0.97 millimeter (mm) is measured, the resistance of the PTC resistance heating layer P**10** (R_P) is about 131.0 ohms (Ω) and the resistance of the NTC resistance heating layer N**10** (R_N) is about 34.1Ω, such that the resistance of the PTC resistance heating layer P**10** is about four times greater than the resistance of the NTC resistance heating layer N**10**. Therefore, in such embodiments, overall change of the total resistance R_T substantially depends on the resistance changing ratio of the PTC resistance heating layer P**10**.

FIGS. **6** and **7** are graphs showing results of measuring resistance changing ratio of embodiments of the resistance heating element **210** having the stacked structure as shown in FIGS. **5**A to **5**D according to thickness ratios T_P/T_N and resistance ratios R_P/R_N of the PTC resistance heating layer P**10** with respect to the NTC resistance heating layer N**10**. FIG. **6** shows the resistance changing ratio in an embodiment where the thickness T_N of the NTC resistance heating layer N**10** and the thickness T_P of the PTC resistance heating layer P**10** are about 0.5 mm and about 0.43 mm, respectively. In such an embodiment, the thickness ratio T_P/T_N is about 0.86, and the resistance ratio R_P/R_N is about 5.2. FIG. **7** shows the resistance changing ratio in an embodiment where the thickness T_N of the NTC resistance heating layer N**10** and the thickness T_P of the PTC resistance heating layer P**10** are about 0.7 mm and about 0.2 mm, respectively. In such an embodiment, the thickness ratio T_P/T_N is about 0.29, and the resistance ratio R_P/R_N is about 15.5.

Referring to FIGS. **6** and **7**, the resistance changing ratio of embodiments of the resistance heating element **210** having the stacked structures shown in FIGS. **5**A to **5**D substantially exhibit NTC characteristics while temperature rises from the room temperature (e.g., about 25° C.) to about 200° C. As shown in FIGS. **6** and **7**, the embodiments of the resistance heating element **210** the PTC on NTC (NTC to PTC) structure and the NTC on PTC (PTC to NTC) structure exhibit a similar resistance changing ratio. In such embodiments, an embodiment of the resistance heating element having the NTC on PTC (PTC to PTC) structure exhibits smaller resistance changing ratio than an embodiment of the resistance heating element having the PTC on NTC (NTC to NTC) structure.

FIGS. **8**A and **8**B show results of simulating current flows through the NTC resistance heating layer N**10** and the PTC resistance heating layer P**10** with respect to the thicknesses of the NTC resistance heating layer N**10** and the PTC resistance heating layer P**10** in an embodiment of the resistance heating element having the PTC on NTC (NTC to NTC) structure and in an embodiment of the resistance heating element having the NTC on PTC (PTC to PTC) structure shown in FIGS. **5**A and **5**D. In the embodiments shown in FIGS. **8**A and **8**B, thickness of the NTC resistance heating layer N**10** is about 0.5 mm, and thickness of the PTC resistance heating layer P**10** is about 0.43 mm. FIG. **8**C is a graph showing current density ratios that are density ratio of a current flowing to the PTC resistance heating layer P**10** with respect to a current flowing to the NTC resistance heating layer N**10** in the embodiments shown in FIGS. **8**A and **8**B.

Referring to FIGS. **8**A to **8**C, when the thicknesses of the NTC resistance heating layer N**10** and the PTC resistance heating layer P10 are predetermined, e.g., about 0.5 mm and about 0.43 mm, respectively, the current density ratios are different when the electrodes **201** and **202** contact the NTC resistance heating layer N10 and when the electrodes **201** and **202** contact the PTC resistance heating layer P10. Referring to FIG. 8C, when the electrodes **201** and **202** contact the PTC resistance heating layer P10 (that is, current path is PTC to PTC), current density ratio is relatively high. Accordingly, substantially high current flows to the PTC resistance heating layer P10 in an embodiment of the resistance heating element having the NTC on PTC (PTC to PTC) structure, and thus the resistance changing ratio of the resistance heating element **210** may be effectively controlled in such an embodiment.

FIGS. 9A and 9B show results of simulating current flows in an embodiment where the thickness of the PTC resistance heating layer P10 is changed with respect to the given thickness of the NTC resistance heating layer N10 in the NTC on PTC (PTC to PTC) structure shown in FIG. 5D. In the embodiments shown in FIGS. 9A and 9B, the thickness of the NTC resistance heating layer N10 is about 0.5 mm. In FIGS. 9A and 9B, thicknesses of the PTC resistance heating layer P10 are about 0.5 mm and about 0.2 mm, respectively. FIG. 9C shows current density ratios that are density ratios of a current flowing to the PTC resistance heating layer P10 with respect to a current flowing to the NTC resistance heating layer N10 in the embodiments shown in FIGS. 9A and 9B. Referring to FIGS. 9A to 9C, in an embodiment, density of a current flowing into the PTC resistance heating layer P10 increases as thickness of the PTC resistance heating layer P10 increases. In such an embodiment, by fixing the thickness of the NTC resistance heating layer N10 and changing the thickness of the PTC resistance heating layer P10, the current density ratio between currents flowing into the PTC resistance heating layer P10 and the NTC resistance heating layer N10 may be effectively controlled. In such an embodiment, the resistance changing ratio of the resistance heating element **210** may be controlled by controlling a current density ratio.

Table 1 below shows resistance changing ratios of an embodiment of the resistance heating element having the NTC on PTC (PTC to PTC) structure (e.g., the embodiment shown in FIG. 5D) and an embodiment of the resistance heating element having the PTC on NTC (NTC to NTC) structure (e.g., the embodiment shown in FIG. 5A) that are measured by changing the resistance ratio R_P/R_N between the PTC resistance heating layer P10 and the NTC resistance heating layer N10 while the temperature rises from the room temperature to about 200° C. In an embodiment, the resistance heating elements **210** having different resistance ratios R_P/R_N are provided by changing the thickness ratio T_P/T_N. Referring to Table 1, the resistance heating element **210** exhibiting a change of resistance within about ±10% may be provided by appropriately selecting the R_P/R_N and the current path.

TABLE 1

Thickness Ratio (T_P/T_N)	0.86		0.29	
Resistance Ratio (R_P/R_N)	5.2		15.5	
Stacked Structure	PTC on NTC	NTC on PTC	PTC on NTC	NTC on PTC
Current Path	NTC to NTC	PTC to PTC	NTC to NTC	PTC to PTC
Change of Resistance	−38%	+0.8%	−48.6%	−8.8%

Based on the above result shown in Table 1, a structure of an embodiment of the resistance heating element may be determined.

In an embodiment, to reduce the resistance changing ratio of the resistance heating element **210** having a stacked structure according to temperature, the electrodes **201** and **202** may be connected to the resistance layer among NTC resistance heating layer N10 and the PTC resistance heating layer P10, which exhibits greater resistance. In such an embodiment, to reduce the resistance changing ratio of the resistance heating element **210** having a stacked structure according to temperature, the resistance changing ratio of one of the NTC resistance heating layer N10 and the PTC resistance heating layer P10, in which more current flows, may be smaller than the resistance changing ratio of the other of the NTC resistance heating layer N10 and the PTC resistance heating layer P10.

In one embodiment, for example, the resistance heating element corresponding to one of four cases shown in Table 2 below may be considered. In one embodiment corresponding to the case 2, the electrodes **201** and **202** are disposed on the PTC resistance heating layer P10 having relatively large resistance, and thus more current flows to the NTC resistance heating layer N10 having relatively small resistance. However, since the NTC resistance heating layer N10 exhibits greater resistance changing ratio, the overall resistance changing ratio is substantially great. In one embodiment corresponding to the case 3, the electrodes **201** and **202** are disposed on the NTC resistance heating layer N10 having relatively large resistance, and thus more current flows to the PTC resistance heating layer P10 having relatively small resistance. However, since the PTC resistance heating layer P10 exhibits greater resistance changing ratio, the overall resistance changing ratio is also substantially great. In embodiments corresponding to the case 1 and case 4, the resistance changing ratio of the resistance heating element **210** is substantially reduced.

TABLE 2

	Resistance Changing Ratio		Resistance		Electrode
	NTC	PTC	NTC	PTC	Location
Case 1	>		>		N
Case 2	>		<		P
Case 3	<		>		N
Case 4	<		<		P

In an embodiment, the resistance changing ratio of the resistance heating element **210** having the stacked structure according to temperature may be controlled to be within a predetermined range, e.g., about ±40% (in an alternative embodiment, about ±10%) by changing the resistance ratio R_P/R_N between the PTC resistance heating layer P10 and the NTC resistance heating layer N10 in the stacked structure. In such an embodiment, the resistance ratio R_P/R_N may be controlled by controlling the thickness ratio T_P/T_N. In such an embodiment, the resistance ratio R_P/R_N may be controlled by changing types and contents of the electroconductive fillers. The mechanical characteristics of the resistance heating element **210** are affected by types and contents of the electroconductive fillers. Therefore, contents of the electroconductive fillers that may be included in the resistance heating element **210** are limited. In such an embodiment, the resistance ratio R_P/R_N may be effectively controlled by controlling the thickness ratio T_P/T_N.

In an embodiment, the resistance heating element **210** may have the NTC on PTC (PTC to PTC) structure to reduce resistance changing ratio. In such an embodiment, to reduce resistance changing ratio, the electrodes **201** and **202** may contact the PTC resistance heating layer P**10**.

The resistance changing ratio of the resistance heating element **210** is mainly affected by the resistance changing ratios of the PTC resistance heating layer P**10** and the NTC resistance heating layer N**10** at a temperature in a range from the room temperatures to about 50° C. Referring back to FIG. **1**, the resistance changing ratio of the PTC resistance heating layer P**10** rapidly increases at the temperatures from the room temperature to about 50° C., and the resistance changing ratio of the NTC resistance heating layer N**10** at a temperature equal to or greater than about 50° C. is less than or equal to about 15%. Therefore, the resistance ratio R_P/R_N may be controlled to make the resistance changing ratio of the resistance heating element **210** to be within a predetermined range at the temperatures in the range from the room temperatures to about 50° C., thereby effectively maintaining a substantially small resistance changing ratio at a predetermined temperature range.

FIG. **10** is a graph showing relationships between the resistance ratio R_P/R_N and the resistance changing ratio of an embodiment of the resistance heating element **210** according to temperature. In one embodiment, for example, the PTC resistance heating layer P**10** is provided by dispersing about 150 phr of carbon black into PDMS, and the NTC resistance heating layer N**10** is provided by dispersing about 12 phr of MWCNTs having an aspect ratio equal to or greater than 150 into PDMS. A range of a resistance ratio R_P/R_N corresponding to the resistance changing ratio equal to or less than about ±10% or equal to or less than about ±40% at 30° C., 35° C., 40° C., and 48° C. may be determined or may be set to have a predetermined value. To satisfy the of the resistance ratio R_P/R_N equal to or less than about ±10% or equal to or less than about ±40%, the thickness ratio T_P/T_N or types and/or contents of electroconductive fillers dispersed into the PTC resistance heating layer P**10** and the NTC resistance heating layer N**10** may be determined. Referring back to FIG. **1**, resistance of the commonly fabricated PTC resistance heating layer P**10** is greater than resistance of the NTC resistance heating layer N**10**. Therefore, to embody the resistance heating element **210**, which has a stacked structure and exhibits a resistance changing ratio of equal to or less than about ±40%, the resistance ratio R_P/R_N may be 2 or greater, and more particularly, the resistance ratio R_P/R_N may be in a range from about 4 to about 6.

(3) Island Structure

FIG. **11** shows an embodiment of a resistance heating element **220** having a stacked structure according to the invention. In such an embodiment, the resistance heating element **220** has a modified stacked structure in which the PTC resistance heating layer P**10** or the NTC resistance heating layer N**10** is arranged as an island. In such an embodiment, as shown in FIG. **11**, the resistance heating element **220** has a PTC on NTC structure, in which first and second portions of the PTC resistance heating layer P**10-1** and P**10-2** are arranged to be spaced apart from each other as islands. The NTC resistance heating layer N**10** is disposed between and on the first and second portions of the PTC resistance heating layer P**10-1** and P**10-2**. The electrodes **201** and **202** contact exposed surfaces of the first and second portions of the PTC resistance heating layer P**10-1** and P**10-2**, respectively. The first and second portions of the PTC resistance heating layer P**10-1** and P**10-2** may include substantially the same material as each other. In such an embodiment, the first and second portions of the PTC resistance heating layer P**10-1** and P**10-2** may be provided by dispersing a same amount of particle type electroconductive fillers in same base polymers.

The embodiment shown in FIG. **11** is substantially the same as the embodiment described above. In such an embodiment, to reduce the resistance changing ratio of the resistance heating element **220** according to temperature, the electrodes **201** and **202** may be connected to one of the NTC resistance heating layer N**10** and the first and second portions of the PTC resistance heating layer P**10-1** and P**10-2**, which exhibits greater resistance, and the resistance changing ratio of one of the NTC resistance heating layer N**10** and the first and second portions of the PTC resistance heating layer P**10-1** and P**10-2**, in which more current flows, may be smaller than resistance changing ratio of the other of the NTC resistance heating layer N**10** and the first and second portions of the PTC resistance heating layer P**10-1** and P**10-2**. In such an embodiment, by changing the resistance ratio R_P/R_N between the first and second portions of the PTC resistance heating layer P**10-1** and P**10-2** and the NTC resistance heating layer N**10** in the stacked structure, the resistance changing ratio of the resistance heating element **220** having the stacked structure according to temperature may be controlled to be within a predetermined range, e.g., about ±40% (more particularly, about ±10%)

FIG. **12** is a graph showing resistance changing ratios of an embodiment of the resistance heating element **220** according to temperature, where the thickness ratios T_P/T_N are about 0.35 and about 1.42, respectively. In one embodiment, for example, the first and second portions of the PTC resistance heating layer P**10-1** and P**10-2** are provided by dispersing about 150 phr of carbon black into PDMS, and the NTC resistance heating layer N**10** is provided by dispersing about 12 phr of MWCNTs having an aspect ratio equal to or greater than 150 into PDMS. Referring to FIG. **12**, resistance changing ratios vary according to the thickness ratios T_P/T_N. Since the resistance ratio R_P/R_N may be changed by changing the thickness ratio T_P/T_N, the resistance heating element **220**, which has the island structure and exhibits a predetermined resistance changing ratio, may be provided by controlling the resistance ratio R_P/R_N.

FIG. **13**A is a graph showing resistance changing ratios in an embodiment where lengths, by which the electrodes **201** and **202** contact the resistance heating element **220** having the island structure and thickness ratio T_P/T_N of 0.35, are about 4.1 mm and about 2.8 mm, respectively. FIG. **13**B is a graph showing resistance changing ratios in an embodiment where lengths, by which the electrodes **201** and **202** contact the resistance heating element **220** having the island structure and thickness ratio T_P/T_N of 0.91, are about 6.0 mm and about 4.1 mm, respectively. FIG. **13**C is a graph showing resistance changing ratios in an embodiment where lengths, by which the electrodes **201** and **202** contact the resistance heating element **220** having the island structure and thickness ratio T_P/T_N of 1.42, are about 10.0 mm and about 4.1 mm, respectively. As shown in FIGS. **13**A, **13**B and **13**C, the resistance changing ratio of an embodiment of the resistance heating element **220** may be controlled to be within a predetermined range by changing lengths by which the electrodes **201** and **202** contact the resistance heating element **220**.

FIG. **14** is a graph showing resistance changing ratios in embodiments of the resistance heating element **220** having the island structure and the thickness ratio T_P/T_N of 1.42, where distances L between the electrodes **201** and **202** are about 32.6 mm, about 20.8 mm, and about 13.3 mm, respectively. Resistance changing ratios and warm-up times from the room temperature to 180° C. of the embodiments are shown in Table 3. As shown in FIG. **14** and Table 3, the resistance changing ratio of the resistance heating element **220** having the island structure may be controlled by controlling the distance L between the electrodes **201** and **202**, that is, a conducting length.

TABLE 3

Conducting Length(mm)	32.6	20.8	13.3
Initial Resistance(Ω)	47.8	39.4	33.8
Resistance Changing Ratio (%)	−8.2	+3	+3
Warm-up Time (sec)	50	18	10

As described above, an embodiment of the resistance heating element **210** and the resistance heating element **220** exhibiting resistance changing ratios within about ±40% or about ±10% may be provided by combining the PTC resistance heating layer P**10** which exhibits a resistance changing ratio of exceeding about ±40% or about ±10% and the NTC resistance heating layer N**10**.

FIG. **15** is a diagram showing an embodiment of electrophotographic image forming apparatus including a heating member and a fusing device according to the invention. Referring to FIG. **15**, a printing unit **100** and a fusing device **300** for printing an image on a printing medium in an electrophotographic process are shown. An embodiment of the image forming apparatus shown in FIG. **15** may be a dry type electrophotographic image forming apparatus, which prints a color image using a dry type developer (referred to hereinafter as ‘toner’).

The printing unit **100** includes an exposing unit **30**, a developing unit **10** and a transfer unit. To print a color image, an embodiment of the printing unit **100** includes four developing units **10**C, **10**M, **10**Y and **10**K in which toners of different colors, e.g., cyan (C) toner, magenta (M) toner, yellow (Y) toner and black (K) toner, are respectively accommodated, and four exposing units **30**C, **30**M, **30**Y and **30**K, corresponding to the developing units **10**C, **10**M, **10**Y and **10**K, respectively.

Each of the developing units **10**C, **10**M, **10**Y and **10**K includes a photosensitive drum **11**, which is an image receptor, on which an electrostatic latent image is formed, and a developing roller **12** for developing the electrostatic latent image. A charge bias voltage is applied to a charge roller **13** of each of the developing units **10**C, **10**M, **10**Y and **10**K to charge the outer surface of the photosensitive drum **11** to a uniform electric potential. In an alternative embodiment, a coroner discharger (not shown) may be provided instead of the charge roller **13**. The developing roller **12** attaches toner to the outer surface thereof and supplies the toner to the photosensitive drum **11**. A developing bias voltage for supplying toner to the photosensitive drum **11** is applied to the developing roller **12**. In an embodiment, each of the developing units **10**C, **10**M, **10**Y and **10**K may further include a supplying roller (not shown) for attaching toner accommodated therein to the developing roller **12**, a regulation unit (not shown) for regulating amount of toner attached to the developing roller **12**, an agitator (not shown) which transports toner accommodated therein toward the supplying roller and/or the developing roller **12**, for example. In an embodiment, each of the developing units **10**C, **10**M, **10**Y and **10**K may further include a cleaning blade (not shown) for removing toner attached to the outer surface of the photosensitive drum **11** before the photosensitive drum **11** is charged and an accommodating space (not shown) for accommodating the removed toner.

In an embodiment, as shown in FIG. **15**, the transfer unit may include a printing medium transferring belt **20** and four transfer rollers **40**. The printing medium transferring belt **20** disposed facing the outer surfaces of the photosensitive drums **11** exposed out of the developing units **10**C, **10**M, **10**Y and **10**K. The printing medium transferring belt **20** is supported by a plurality of supporting rollers **21**, **22**, **23** and **24** and circulates. In such an embodiment, the printing medium transferring belt **20** is installed substantially in a vertical direction, e.g., a vertical direction with respect to a bottom surface of the printing unit **100**. The four transfer rollers **40** are disposed to face the photosensitive drums **11** of the developing units **10**C, **10**M, **10**Y and **10**K, respectively, while interposing the printing medium transferring belt **20** therebetween. Transfer bias voltage is applied to the transfer rollers **40**. The exposing units **30**C, **30**M, **30**Y and **30**K scan lights corresponding to cyan (C), magenta (M), yellow (Y) and black (K) image data to the photosensitive drums **11** of the developing units **10**C, **10**M, **10**Y and **10**K, respectively. In such an embodiment, laser scanning units (“LSU”) which include laser diodes as light sources may be provided as the exposing units **30**C, **30**M, **30**Y and **30**K.

Hereinafter, an embodiment of a process of forming a color image using the embodiment of electrophotographic image forming apparatus shown in FIG. **15** will be described in detail.

The photosensitive drum **11** of each of the developing units **10**C, **10**M, **10**Y and **10**K is charged to a uniform electric potential by a charge bias voltage applied to the charge roller **13**. The four exposing units **30**C, **30**M, **30**Y and **30**K form electrostatic latent images by scanning lights corresponding to cyan (C), magenta (M), yellow (Y) and black (K) image data to the photosensitive drums **11** of the developing units **10**C, **10**M, **10**Y and **10**K, respectively. Developing bias voltage is applied to the developing rollers **12**. Then, toners attached to the outer surfaces of the developing rollers **12** are attached to the electrostatic latent images, and cyan (C), magenta (M), yellow (Y) and black (K) toner images are formed on the photosensitive drums **11** of the developing units **10**C, **10**M, **10**Y and **10**K, respectively.

A medium for final accommodation of toner images, e.g., a printing medium P, is picked up from a cassette **120** by a pickup roller **121**. The printing medium P is introduced to the printing medium transferring belt **20** by the transfer roller **122**. The printing medium P is attached to a surface of the printing medium transferring belt **20** via electrostatic force and is transferred at substantially the same speed as the speed at which the printing medium transferring belt **20** is driven.

In one embodiment, for example, a leading edge of the printing medium P reaches a transfer nib at a time point, at which a leading edge of a cyan (C) toner image formed on the outer surface of the photosensitive drum **11** of the developing unit **10**C reaches the transfer nib. When transfer bias voltage is applied to the transfer roller **40**, the toner image formed on the photosensitive drum **11** is transferred to the printing medium P. As the printing medium P is being transferred, the magenta (M), yellow (Y) and black (K) toner images formed on the photosensitive drums **11** of the developing units **10**M, **10**Y and **10**K are sequentially transferred and superimposed onto the printing medium P, and thus a color toner image is formed on the printing medium P.

The color toner image transferred to the printing medium P is maintained on the surface of the printing medium P by electrostatic force. The fusing device **300** fuses the color toner image to the printing medium P by applying heat and pressure. The fused printing medium P is discharged out of the image forming apparatus by a discharging roller **123**.

In such an embodiment, the fusing device **300** is heated to a temperature close to a predetermined fusing temperature to form an image. The shorter the warm-up time is, the faster the first page may be printed out after a printing command is received. Generally, the fusing device **300** may only be heated during a printing task and may not be operated in stand-by mode. However, when another printing task is started, the fusing device **300** is re-heated. In an embodiment, to reduce the period of time elapsed for starting another printing task, the fusing device **300** may be controlled to maintain a predetermined temperature in stand-by mode. In such an embodiment, the temperature of the fusing device **300** in the stand-by mode may be maintained at a predetermined temperature, e.g., a temperature in a range from about 120° C. to about 180° C. In an embodiment, where a period of time elapsed for heating the fusing device **300** to a temperature for performing a printing task is sufficiently reduced, the fusing device **300** may be maintained at a temperature lower than the predetermined temperature in stand-by mode, and thus energy consumed by the fusing device **300** may be reduced.

FIG. **16** is a diagram showing an embodiment of the fusing device **300** according to the invention. In an embodiment, as shown in FIG. **16**, the fusing device **300** may be a roller-type fusing device including a roller-type heating member. Referring to FIG. **16**, the fusing device **300** includes a heating member **310** and a nib forming unit facing the heating member **310**, and the heating member **310** and the nib forming unit collectively defined a fusing nib **301**. In such an embodiment, the heating member **310** includes a resistance heating element **312**, a supporting unit **311** that supports the resistance heating element **312**, and a releasing layer **314**. The nib forming unit includes a pressing member **320** facing the heating member **310**. The heating member **310** and the pressing member **320** are biased by a bias unit (not shown) such as a spring in direction to engage with each other. In one embodiment, for example, the pressing member **320** is a roller-like member including a metal support **321** and an elastic layer **322** disposed on the metal support **321**. In such an embodiment, as the elastic layer **322** of the pressing member **320** is partially deformed, the fusing nib **301**, via which heat is transferred from the heating member **310** to a toner on the printing medium P, is formed. The heating member **310**, which is a roller-like member as shown in FIG. **16**, of the fusing device **300** of an electrophotographic image forming apparatus is generally referred to as a fusing roller.

FIG. **17** shows an alternative embodiment of the fusing device **300** according to the invention. The embodiment of the fusing device **300** shown in FIG. **17** is substantially the same as the embodiment of the fusing device **300** shown in FIG. **15** except for the heating member **310** having a belt-like supporting unit **311**. The heating member **310** as shown in FIG. **17** is generally referred to as a fusing belt. Referring to FIG. **17**, the nib forming unit may include the pressing member **320** and a nib forming member **340** that is arranged inside the belt-like heating member **310** forming a closed-loop. The pressing member **320** is arranged outside the heating member **310**. In such an embodiment, to form the fusing nib **301**, the nib forming member **340** and the pressing member **320** are engaged with each other and rotate while interposing the heating member **310** therebetween. A bias unit (not shown) applies elastic force to the nib forming member **340** and/or the pressing member **320** in direction in which the nib forming member **340** and the pressing member **320** engage with each other. In one embodiment, for example, the nib forming member **340** may be pressed toward the pressing member **320**. In an embodiment, the nib forming member **340** may be an elastic roller type member (not shown) that rotates together with the pressing member **320** and drives the heating member **310**.

FIGS. **18** to **21** are schematic cross-sectional views of embodiments of the heating member **310** of the fusing devices **300** shown in FIGS. **16** and **17**. The heating member **310** may include a resistance heating element **312** and a supporting unit **311** that supports the resistance heating element **312**. A releasing layer **314** may be further provided on outer surfaces of the resistance heating element **312**. An elastic layer **313** may be further arranged between the resistance heating element **312** and the releasing layer **314** to secure the sufficient fusing nib **301**. The elastic layer **313** may include a same material as the base polymer of the resistance heating element **312** and/or the releasing layer **314**.

In an embodiment, the supporting unit **311** may include a polymer-based material, e.g., polyimide, polyimideamide and fluoropolymers, for example, or a metal. In such an embodiment, the fluoropolymers may include fluorinated PEEK, PTFE, PFA and FEP, for example. In such an embodiment, the metal may include a stainless steel, nickel, copper, brass, and alloys thereof. However, materials for forming the supporting unit **311** are not limited to the materials stated above. In an embodiment, where the supporting unit **311** includes a conductive metal, an insulation layer (not shown) may be interposed between the supporting unit **311** and the resistance heating element **312**. In an embodiment, an insulation layer (not shown) may be interposed between electrodes **315** and **316**, which will be described below, and the supporting unit **311**.

In an embodiment including a roller-type heating member, the supporting unit **311** may have a hollow pipe-like shape. In such an embodiment, the supporting unit **311** may include a material having a substantially high hardness to not to be excessively deformed by a pressure for forming the fusing nib **301**. In an embodiment of a belt-type heating member, the supporting unit **311** may be configured to have a sufficient flexibility to be flexibly deformed at the fusing nib **301** and to be recovered from the deformation after the supporting unit **311** passes the fusing nib **301**.

The releasing layer **314** defines the outermost layer of the heating member **310**. During a fusing process, an offset, in which a toner on the printing medium P is fused and attached to the heating member **310**, may occur. The offset may cause a printing defect that may occur when an image printed on the printing medium P is partially omitted and a jam that may occur when the printing medium P passed a fusing nib is not separated from the heating member **310** and is attached to a surface of the heating member **310**. The releasing layer **314** may include a highly releasable polymer layer to effectively prevent a toner from being attached to the heating member **310**. The releasing layer **314** may include a silicon-based polymer or a fluorine-based polymer, for example. The fluorine-based polymer may be polyperfluoroethers, fluorinated polyethers, fluorinated polyimides, PEEK, fluorinated polyamides, fluorinated polyesters, etc., for example. The releasing layer **314** may be one of the above-stated polymers, or a blend or copolymer of two or more of the above-stated polymers.

In such an embodiment, the electrodes **315** and **316** are arranged on the supporting unit **311** to be apart from each other in the width-wise direction and contact the resistance heating element **312**. Current is supplied to the resistance heating element **312** via the electrodes **315** and **316**. In one embodiment, for example, the electrodes **315** and **316** may be an input electrode and an output electrode respectively. The electrodes **315** and **316** may include a highly conductive metal, e.g., copper, silver, etc.

When the resistance heating element **312** is driven by a constant voltage (V), input power input to the resistance heating element **312** may be indicated as V^2/R, where R denotes the resistance of the resistance heating element **312**. Accordingly, if the resistance R of the resistance heating element **312** is changed, the input power is changed. If the resistance R of the resistance heating element **312** gradually decreases or increases during warm-up, the input power gradually increase or decreases. In an embodiment, the input power may be restricted such that an excessive current flow is effectively prevented when the resistance of the resistance heating element **312** is decreased, and thus the resistance heating element **312** may be effectively prevented from being overheated during warm-up. Excessive current may cause a thermal shock to a base polymer and deteriorates durability of the resistance heating element **312**, and thus risk of overheating or fire due to the overheating may increase. Therefore, in such an embodiment, the maximum input power is set to not to overheat the resistance heating element **312** based on the lowest resistance of the resistance heating element **312**. In such an embodiment, where the resistance changing ratio of the resistance heating element **312** is large, the upper limit of the maximum input power is substantially lowered, thereby increasing warm-up time. In such an embodiment, the resistance changing ratio of the resistance heating element **312** is substantially reduced while temperature rises from the room temperature to a fusing temperature (e.g., 200° C.) to be, for example, within about ±10% range to effectively prevent overheat and reduce warm-up time.

FIG. **18** is a schematic cross-sectional diagram of an embodiment of the heating member **310** of the fusing devices **300** shown in FIGS. **16** and **17**. In such an embodiment, the heating member **310** includes the resistance heating element (**200** of FIG. **3**) having the hybrid structure, in which particle type electroconductive fillers and fiber type electroconductive fillers are dispersed in a base polymer. The particle type electroconductive fillers may be electroconductive fillers having an aspect ratio less than about 10, and the fiber type electroconductive fillers may be electroconductive fillers having an aspect ratio equal to or greater than about 10. In one embodiment, for example, the particle type electroconductive fillers may be carbon black or fullerene, and the fiber type electroconductive fillers may be CNTs. In such an embodiment, contents of the particle type electroconductive fillers and the fiber type electroconductive fillers may have predetermined values, such that the resistance changing ratio of the resistance heating element **312** during warm-up is, for example, within about ±10%. In an embodiment, where content of the particle electroconductive fillers is high, the resistance heating element **312** may exhibit overall PTC characteristics, where the fiber type electroconductive fillers function as conductive bridges between the particle type electroconductive fillers and buffers the PTC characteristics. In an embodiment, where content of the fiber type electroconductive fillers is high, the resistance heating element **312** may exhibit overall NTC characteristics, where PTC characteristics of the particle type electroconductive fillers may buffer the NTC characteristics. As described above, in an embodiment, the resistance heating element **312** having a predetermined resistance changing ratio may be provided by effectively controlling contents of the particle type electroconductive fillers and the fiber type electroconductive fillers. In an embodiment, as contents of electroconductive fillers increase, electric conductivity of the resistance heating element **312** increases, and thus the fusing device **300** may be warmed up quickly. However, in such an embodiment, the resistance heating element **312** may have an excessive stiffness. The resistance heating element **312** and the pressing member **320** collectively define the fusing nib **301**. Here, if the resistance heating element **312** has an excessive stiffness, the fusing nib **301** having a sufficient size may not be effectively formed. Furthermore, high stiffness may deteriorate mechanical properties of the resistance heating element **312**, thereby deteriorating lifespan of the heating member **310**. Therefore, in such an embodiment, contents of the electroconductive fillers is set to have a predetermined value based on the mechanical properties of the resistance heating element **312** and size of the fusing nib **301** of the fusing device **300**.

FIG. **19** is a schematic cross-sectional view of an alternative embodiment of the heating member **310** of the fusing devices **300** shown in FIGS. **16** and **17**. In such an embodiment, the heating member **310** includes the resistance heating element **210** having the stacked structure as shown in FIGS. **5**A to **5**D as the resistance heating element **312**. The stacked structure may be the NTC on PTC structure or the PTC on NTC structure. The current path may be the NTC to PTC structure, the PTC to NTC structure, the NTC to NTC structure, or the PTC to PTC structure. In an embodiment, the resistance heating element **210** may have the NTC to NTC structure or the PTC to PTC structure such that a substantially small resistance changing ratio may be obtained. Also, the input electrode **315** and the output electrode **316** are connected to one of the NTC resistance heating layer N**10** and the PTC resistance heating layer P**10**, which has greater resistance. The other of the NTC resistance heating layer N**10** and the PTC resistance heating layer P**10**, to which the electrodes **315** and **316** are not connected, provides the main path of a current, and thus content of electroconductive fillers in the other of the NTC resistance heating layer N**10** and the PTC resistance heating layer P**10** to which the electrodes **315** and **316** are not connected, may be determined or set to have a predetermined value to have a smaller resistance changing ratio than the one of the NTC resistance heating layer N**10** and the PTC resistance heating layer P**10** to which the electrodes **315** and **316** are connected. In an embodiment, as shown in FIG. **19**, the resistance heating element **312** has the NTC on PTC (PTC to PTC) structure. In such an embodiment, the electrodes **315** and **316** are arranged at both sides of the supporting unit **311** in the width-wise direction, and the PTC resistance heating layer P**10** is configured to contact the electrodes **315** and **316**. The NTC resistance heating layer N**10** is arranged on the PTC resistance heating layer P**10**. In an embodiment, the elastic layer **313** and/or the releasing layer **314** may be further arranged on the NTC resistance heating layer N**10**. As described above with reference to FIGS. **6**, **7**, **8**A to **8**C, **9**A to **9**C, and **10**, the resistance heating element **312** has a resistance changing ratio within a predetermined range (e.g., about ±10%) by controlling the resistance ratio R_P/R_N between the NTC resistance heating layer N**10** and the PTC resistance heating layer P**10**. The resistance ratio R_P/R_N may be controlled by controlling the thickness ratio T_P/T_N and/or contents of the electroconductive fillers.

FIG. **20** is a schematic cross-sectional view of another alternative embodiment of the heating member **310** of the fusing devices **300** shown in FIGS. **16** and **17**. In such an embodiment, the heating member **310** includes the resistance heating element **220** having the island structure as shown in FIG. **11** as the resistance heating element **312**. The island structure may be a stacked structure, e.g., the NTC on PTC structure or the PTC on NTC structure. The current path may be the NTC to NTC structure or the PTC to PTC structure. In an embodiment, the input electrode **315** and the output electrode **316** may be connected to one of the NTC resistance heating layer N10 and the first and second portions of the PTC resistance heating layer P10-1 and P10-2, which has greater resistance, to obtain a substantially small resistance changing ratio. Content of electroconductive fillers in the other of the NTC resistance heating layer N10 and the first and second portions of the PTC resistance heating layer P10-1 and P10-2, to which the electrodes 315 and 316 are not connected, operates as the main path of a current, content of electroconductive fillers in the other of the NTC resistance heating layer N10 and the first and second portions of the PTC resistance heating layer P10-1 and P10-2, to which the electrodes 315 and 316 are not connected may be configured to have a smaller resistance changing ratio than the one of the NTC resistance heating layer N10 and the first and second portions of the PTC resistance heating layer P10-1 and P10-2, to which the electrodes 315 and 316 are not connected to which the electrodes 315 and 316 are connected. In an embodiment, as shown in FIG. 20, the resistance heating element 312 may have the NTC on PTC (PTC to PTC) structure. The electrodes 315 and 316 are arranged at both sides of the supporting unit 311 in the width-wise direction, and the first and second portions of the PTC resistance heating layer P10-1 and P10-2 are arranged as islands to contact the electrodes 315 and 316, respectively. The NTC resistance heating layer N10 is arranged between the first and second PTC resistance heating layers P10-1 and P10-2 and on the first and second PTC resistance heating layers P10-1 and P10-2. In an embodiment, the first and second PTC resistance heating layers P10-1 and P10-2 may include substantially the same material as each other. In such an embodiment, the first and second PTC resistance heating layers P10-1 and P10-2 may be provided by dispersing a same amount of particle type electroconductive fillers in same base polymers.

As described above with reference to FIGS. 6, 7, 8A to 8C, 9A to 9C, and 10, an embodiment of the resistance heating element 312 has a resistance changing ratio within a predetermined range (e.g., about ±10%) by controlling the resistance ratio R_P/R_N between the NTC resistance heating layer N10 and the PTC resistance heating layer P10. The resistance ratio R_P/R_N may be controlled by controlling the thickness ratio T_P/T_N and/or contents of the electroconductive fillers. In an embodiment, as described above with reference to FIGS. 13A to 13C and 14, the resistance heating element 312 has a resistance changing ratio within a predetermined range (e.g., about ±10%) by controlling lengths by which the electrodes 315 and 316 contact the first and second PTC resistance heating layers P10-1 and P10-2 and/or a conductive length (a distance between the electrodes 315 and 316).

(4) Serial Structure

FIG. 21 is a schematic cross-sectional view of another alternative embodiment of the heating member 310 of the fusing devices 300 shown in FIGS. 16 and 17. In such an embodiment, the heating member 310 may include the resistance heating element 312 having a structure substantially the same as the structure of the resistance heating element 220 having the island structure shown in FIG. 11 except that the PTC resistance heating layer P10 and the NTC resistance heating layer N10 are connected in series. In such an embodiment, the structure of the resistance heating element 312 may be PTC-NTC-PTC structure or NTC-PTC-NTC structure. In one embodiment, as shown in FIG. 21, for example, the resistance heating element 312 may be the PTC-NTC-PTC type resistance heating element 312. The electrodes 315 and 316 are arranged at both sides of the supporting unit 311 in the width-wise direction. The first and second PTC resistance heating layers P10-1 and P10-2 are arranged to contact the electrodes 315 and 316, respectively. The NTC resistance heating layer N10 is arranged between the first and second PTC resistance heating layers P10-1 and P10-2. In an embodiment, the first and second PTC resistance heating layers P10-1 and P10-2 may include substantially the same material as each other. In such an embodiment, the first and second PTC resistance heating layers P10-1 and P10-2 may be provided by dispersing a same amount of particle type electroconductive fillers in same base polymers.

Power supplied to the resistance heating element 312 during a fusing process is controlled to maintain temperature of the resistance heating element 312 at a fusing temperature, e.g., about 180° C. In general, width W1 of the resistance heating element 312 in the heating member 310 is greater than width W2 of a feeding region FR1 at which the printing medium P passes for fusion. The two opposite ends of the feeding region FR1 is a non-feeding region FR2 in which the printing medium P does not pass. Heat is transferred from the resistance heating element 312 to the printing medium P in the feeding region FR1, where the power supplied to the resistance heating element 312 is controlled based on the heat transfer to maintain the entire resistance heating element 312 at the fusing temperature. However, heat is not transferred in the non-feeding region FR2, the non-feeding region FR2 may be overheated to a temperature exceeding the fusing temperature. Repeated overheating of the non-feeding region FR2 may cause damages to the resistance heating element 312 and the heating member 310. As shown in FIG. 1, resistances of the first and second PTC resistance heating layers P10-1 and P10-2 rapidly increase as temperatures thereof exceed about 40° C., and currents flowing therein rapidly decrease. Therefore, in such an embodiment, the non-feeding region FR2 may be effectively prevented from being overheated by the first and second PTC resistance heating layers P10-1 and P10-2 in the non-feeding region FR2. The electrodes 315 and 316 may contact only the first and second PTC resistance heating layers P10-1 and P10-2. In such an embodiment, as shown in FIG. 21 by dotted lines, the electrodes 315 and 316 may partially contact the NTC resistance heating layer N10.

The above embodiments are described in relation to a case where a resistance heating element and a heating member are applied to a fusing device of an electrophotographic image forming apparatus. However, applications of the resistance heating element and the heating members are not limited thereto, and the resistance heating element and the heating members may be applied to any of various devices including a heat generating unit for generating heat using electricity.

It should be understood that the exemplary embodiments described therein should be considered in a descriptive sense only and not for purposes of limitation. Descriptions of features or aspects within each embodiment should typically be considered as available for other similar features or aspects in other embodiments.

What is claimed is:

1. A resistance heating element comprising:

a positive temperature coefficient resistance heating layer having a positive temperature coefficient;

a negative temperature coefficient resistance heating layer, which is electrically connected to the positive temperature coefficient resistance heating layer and has a negative temperature coefficient;

wherein

the positive temperature coefficient resistance heating layer comprises:

a first base polymer; and

first electroconductive fillers, which are dispersed in the first base polymer and form a first conductive network, and the negative temperature coefficient resistance heating layer comprises:

a second base polymer; and

second electroconductive fillers, which are dispersed in the second base polymer and form a second conductive network.

2. The resistance heating element of claim 1, wherein

an aspect ratio of the first electroconductive fillers is less than about 10, and

an aspect ratio of the second electroconductive fillers is equal to or greater than about 10.

3. The resistance heating element of claim 1, wherein

a resistance changing ratio of the positive temperature coefficient resistance heating layer according to temperature is equal to or greater than about 10%.

4. The resistance heating element of claim 1, wherein

a resistance changing ratio of the negative temperature coefficient resistance heating layer according to temperature is equal to or greater than about 10%.

5. The resistance heating element of claim 1, further comprising:

an input electrode and an output electrode, which supply currents to the resistance heating element,

wherein

the positive temperature coefficient resistance heating layer and the negative temperature coefficient resistance heating layer have one of a structure in which the positive temperature coefficient resistance heating layer' and the negative temperature coefficient resistance heating layer are stacked, a structure in which the negative temperature coefficient resistance heating layer is arranged on and between first and second portions of the positive temperature coefficient resistance heating layer, which are spaced apart from each other, and a structure in which the negative temperature coefficient resistance heating layer is arranged between the first and second portions of the positive temperature coefficient resistance heating layer, and

the input electrode and the output electrode have one of a structure in which the input electrode and the output electrode are connected to the positive temperature coefficient resistance heating layer, a structure in which the input electrode and the output electrode are connected to the negative temperature coefficient resistance heating layer, and a structure in which the input electrode is connected to one of the positive temperature coefficient resistance heating layer and the negative temperature coefficient resistance heating layer and the output structure is connected to the other of the positive temperature coefficient resistance heating layer and the negative temperature coefficient resistance heating layer.

6. The resistance heating element of claim 1, wherein

a resistance ratio of resistance of the positive temperature coefficient resistance heating layer with respect to resistance of the negative temperature coefficient resistance heating layer has a predetermined value, such a resistance changing ratio of the resistance heating element is within about ±40%.

7. The resistance heating element of claim 1, further comprising:

an input electrode and an output electrode, which supply currents to the resistance heating element,

wherein the input electrode and the output electrode are connected to one of the positive temperature coefficient resistance heating layer and the negative temperature coefficient resistance heating layer, which has greater resistance.

8. The resistance heating element of claim 7, wherein

resistance changing ratio of the other of the positive temperature coefficient resistance heating layer and the negative temperature coefficient resistance heating layer, to which the input electrode and the output electrode are not connected, is less than resistance changing ratio of the one of the positive temperature coefficient resistance heating layer and the negative temperature coefficient resistance heating layer, to which the input electrode and the output electrode are connected.

9. The resistance heating element of claim 7, wherein

the input electrode and the output electrode are connected to the positive temperature coefficient resistance heating layer, and

a resistance ratio of resistance of the positive temperature coefficient resistance heating layer with respect to resistance of the negative temperature coefficient resistance heating layer is greater than or equal to about 2.

10. A heating member comprising:

an input electrode;

an output electrode;

a resistance heating element which generates heat using electricity supplied thereto via the input electrode and the output electrode; and

a supporting unit which supports the resistance heating element,

wherein the resistance heating element comprises:

a positive temperature coefficient resistance heating layer having a positive temperature coefficient; and

a negative temperature coefficient resistance heating layer, which is electrically connected to the positive temperature coefficient resistance heating layer and has a negative temperature coefficient;

wherein

the positive temperature coefficient resistance heating layer comprises:

a first base polymer; and

first electroconductive fillers which are dispersed in the first base polymer and form a first conductive network, and

the negative temperature coefficient resistance heating layer comprises:

a second base polymer; and

second electroconductive fillers which are dispersed in the second base polymer and form a second conductive network.

11. The heating member of claim 10, wherein

an aspect ratio of the first electroconductive fillers is less than about 10, and

an aspect ratio of the second electroconductive fillers is equal to or greater than about 10.

12. The heating member of claim 10, wherein

the positive temperature coefficient resistance heating layer and the negative temperature coefficient resistance heating layer have one of a structure in which the positive temperature coefficient resistance heating layer and the negative temperature coefficient resistance heating layer are stacked, a structure in which the negative temperature coefficient resistance heating layer is arranged on and between first and second portions of the positive temperature coefficient resistance heating layers, which are spaced apart from each other, and a structure in which the negative temperature coefficient resistance heating layer is arranged between the first and second portions of the positive temperature coefficient resistance heating layer, and

the input electrode and the output electrode have one of a structure in which the input electrode and the output electrode are connected to the positive temperature coefficient resistance heating layer, a structure in which the input electrode and the output electrode are connected to the negative temperature coefficient resistance heating layer, and a structure in which the input electrode is connected to one of the positive temperature coefficient resistance heating layer and the negative temperature coefficient resistance heating layer and the output structure is connected to the other of the positive temperature coefficient resistance heating layer and the negative temperature coefficient resistance heating layer.

13. The heating member of claim **12**, wherein

a resistance ratio of resistance of the positive temperature coefficient resistance heating layer with respect to resistance of the negative temperature coefficient resistance heating layer has a predetermined value, such that a resistance changing ratio of the resistance heating element is within about ±10%.

14. The heating member of claim **12**, wherein

the input electrode and the output electrode are connected to one of the positive temperature coefficient resistance heating layer and the negative temperature coefficient resistance heating layer, which has greater resistance.

15. The heating member of claim **14**, wherein

resistance changing ratio of the other of the positive temperature coefficient resistance heating layer and the negative temperature coefficient resistance heating layer, to which the input electrode and the output electrode are not connected, is less than resistance changing ratio of the one of the positive temperature coefficient resistance heating layer and the negative temperature coefficient resistance heating layer, to which the input electrode and the output electrode are connected.

16. The heating member of claim **10**, wherein the supporting unit has a hollow pipe-like shape.

17. The heating member of claim **10**, wherein the supporting unit has a belt-like shape.

18. A fusing device comprising:

a heating member comprising:

an input electrode;

an output electrode;

a resistance heating element which generates heat using electricity supplied thereto via the input electrode and the output electrode; and

a supporting unit which supports the resistance heating element,

wherein the resistance heating element comprises:

a positive temperature coefficient resistance heating layer having a positive temperature coefficient;

a negative temperature coefficient resistance heating layer, which is electrically connected to the positive temperature coefficient resistance heating layer and has a negative temperature coefficient; and

a nib forming unit, which faces the heating member and forms a fusing nib;

wherein

the positive temperature coefficient resistance heating layer comprises:

a first base polymer; and

first electroconductive fillers which are dispersed in the first base polymer and form a first conductive network, and

the negative temperature coefficient resistance heating layer comprises:

a second base polymer; and

second electroconductive fillers which are dispersed in the second base polymer and form a second conductive network.

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